POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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Hydraulic turbine runner damaged by cavitation. Photo by L. F. Harza. Chicago.

15,000 Lb. per Sq. Inch!

DID YOU EVER HEAR of hydraulic turbines operating under pressures of around 15,000 lb. per sq. in.? No? Well, neither did we. It should not be surprising, therefore, to find that where ordinary turbines and water wheels are subjected to pressures of this order, they go to pieces rather quickly. But, perhaps we are getting ahead of our story. "Where in the world" you ask, "are turbines subject to 15,000 lb. pressure?"

The answer to this is rather involved. It is true that nowhere are there hydraulic turbines operating at even one-tenth of this pressure, but under certain conditions, such pressures are liable to occur in machines of the most ordinary head—not throughout the turbine as a whole but in certain minute parts and when they do, they play havoc with the material of which the turbine is made as can be seen from the above photograph.

Now, the experienced hydraulic man looking at this picture will recognize the condition as one produced by cavitation. Then why all this discussion about 15,000 lb. pressure? Well, that's the astonishing part of this whole story. It seems that in the phenomenon of cavitation, the surface of the materials is virtually exploded by small bubbles of compressed gas—bubbles compressed to pressures of as high as 1000 atmospheres! These bubbles coming in contact—but we really must not tell you any more about this here. This is all part of Professor Spannhake's theory of cavitation which appears on page 674 of this issue. Cavitation has long been an extremely troublesome condition in hydraulic turbine operation and this new theory for the first time gives us an indication of how it may be overcome. You may not be interested in hydraulic turbines but it's worth while to read it as it applies to pumping equipment as well.

Saving Space in North Dakota

Trying to save space in North Dakota to us has much the same significance as has the time worn phrase "carrying coals to Newcastle." Speaking as one who has just traveled the length and breadth of this great state, the writer can see no reason why anybody would quibble about a cubic foot more or less of space in North Dakota. Space, it seems, is something they have "nothin' but plenty of." Such is the intentness of civilized man, however, that he will go to any extreme to give expression to his pet ideas. And so, in extending the boiler plant of Armour and Co. at West Fargo, N. D., the engineers by some means or other—a shoe horn we believe—managed to crowd equipment for making 60,000 lb. of steam an hour into an unbelievably small space. From an engineering standpoint, the way in which this was done makes excellent reading but for North Dakota, we still feel, it seems like a misapplication of talent. The article describing this installation is on page 644.

Helping Out the Condenser

A condenser is a hard-working device—usually it tries to do two things at once, first condense whatever it is supposed to condense and second maintain a respectable vacuum. When it is fed with nothing but nice juicy condensable vapors, everything usually runs along fine and you will find the condensers performing both functions efficiently and contentedly. But when you put the condenser on a diet of half vapor and half noncondensable gases, is it any wonder the poor thing gets dyspepsia or indigestion or whatever it is that condensers get? Indeed no—a condenser needs at least as much care as a first rate cow and so when you have a lot of non-condensable gases to dispose of, be considerate; provide your condenser with an automatically controlled vacuum pump. Mr. Hayes shows on page 660 how such a scheme works with a heater installation.

First Comes the Furnace

In these modern times when boilers look like bird cages and coal is squirted into the furnace, we do few things the way we did them in the good old days when wheelbarrows were classified as coal handling equipment. Then, when we needed a new boiler room, we would first decide what size boilers were required. This was the logical starting point in the design of the installation—no one ever doubted its correctness. But, today, even this obvious practice has been turned topsy turvy—today when we start to design a boiler plant, we start with the furnace. Why? Oh, for various reasons which we can't stop to explain here, but if you are interested you will find all of them listed in the article on page 654.

WITH THE EDITORS

Transmission Economics

HIGH VOLTAGE has made possible ever increasing distance of transmission of electric power but it is interesting that, as recently stated by H. P. Liversedge, the average distance of energy flow is now only 22 miles, or excluding the far-west systems, only 17 miles, while only 15 per cent of the total power generated in the country crosses state boundaries. Electric power cannot be stored, must be used as generated and the cost of transmission makes the mass of electric power production essentially a localized industry.

One of the favorite arguments of the advocates of government ownership is a comparison of the operating cost of current at the generator switchboard with rates charged to consumers, whereas it is easily demonstrable that, even for small local systems, the costs of distribution, metering and accounting are many times the cost of fuel and labor and generally greater than total cost at the switchboard. Considering only cost of overhead on investment, for transmission, transformation and distribution, it is 1.6 times that for generation, while for transmission alone it is now, on the average, 0.58 that for generation and increases as distance of transmission becomes greater. This limits very definitely the range for economical transmission except where, as in the far west, large amounts of water power can be developed in regions where fuel prices are high. Even there, records of the Los Angeles district show the ability of local steam stations to compete in cost of current delivered with the long-distance transmitted hydro-electric power.

As Mr. Liversedge points out, most of the interchange of power on interconnected systems is in cases of emergency, or is worked out by passing on power from generating systems to adjacent distribution systems successively over comparatively short distances. The final effect may be transferring of load at the end of the chain to a station some hundreds of miles away but transmission of current is likely to be not over 20 miles in any link of the chain and lack of coincidence of demand is likely to interfere with the economy of such interchanges of power.

While location of hydroelectric plants is determined by the site of the available fall and that of large steam stations by availability of condensing water and economy of fuel delivery, economy demands that stations be located as near as possible to the center of distribution of the load to be carried so that transmission distance be as short as possible.

Advancement Through Perfection of Details

"ACCIDENTS DO not happen, they are caused." This statement in a recent safety bulletin is a truism which bears consideration every time some unplanned and unexpected incident takes place in the plant. Our equipment is built around fundamental principles of strength and endurance of materials employed. Many factors, however, enter into the design and use of equipment which are not foreseen by the original designer, albeit his product may be pronounced a success in practice. The theory of the "one-horse shay" is of course fantastic but is an ideal towards which we must work if improvements are to be made.

Scientific research has been the starting point for practically all of our modern industrial development. It revealed formerly unknown principles underlying qualities of materials and their behavior under treatment of temperature changes, varying stresses, changing chemical constituents, erosion, corrosion and the full gamut of physical and chemical tests as we know them today for materials used in industry. Many scientists are of the opinion that the work has just started and it is certain that industry is many years behind science in applying available knowledge to industrial problems.

Between the pure scientist and the industrialist are needed interpreters capable of applying the discoveries of science to the every day problems of industry. For example, the fundamental causes of corrosion are well known but that peculiar form known as cavitation is the result of a combination of causes including problems in chemistry, hydraulics, machine design and plant operation. A study of steam turbine outages by the prime movers committee of the N.E.L.A. revealed that shutdowns are usually the result of defects developed in the small elemental parts of the unit rather than the major elements. It is noted that blade erosion is becoming an increasingly serious problem; that difficulties resulting from scale accumulation on blades are being overcome by purifying steam and better methods of removing scale; that coupling difficulties have been corrected by better lubrication; that erosion of water glands results from oxygen in the sealing water which can readily be eliminated.

It is only through the correction of such details by better choice of materials, better design features and better operating practice that longer life and greater reliability can be given to power plant equipment and with the increased interest in research, which is evidenced by technical society activity and graduate school attendance, an increasing number of technicians are becoming available to industry for the study and improvement of present practices.

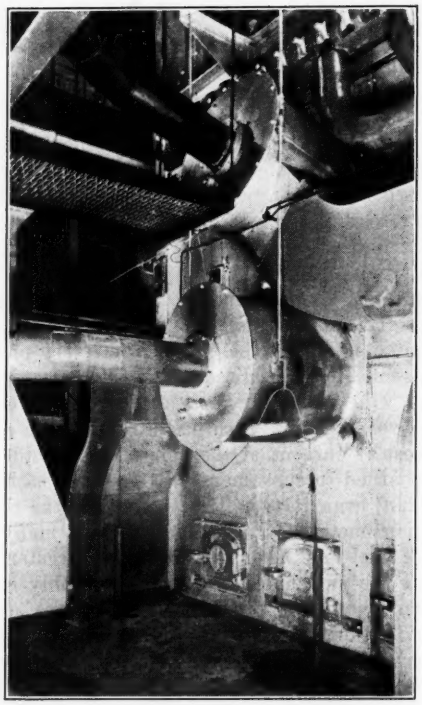
Brighten Up

IT IS DIFFICULT to evaluate the morale of an organization in dollars and cents. There is, however, a definite value in increased coöperation brought about by pleasant surroundings. In an industrial or power plant this comes under the general classification of good housekeeping and its greatest ally is a good, light-colored paint.

Increased pride in the dressed-up appearance of plant and machines will cause greater application, more care and a pride of accomplishment that will repay the small cost. During this trying period the good effects will be triple: The job can be done cheaper than ever before; employment is increased and conditions made more agreeable for those few who are fortunate enough to be employed. Dividends in the form of increased coöperation and good will are sure to be ample and the effect on prospective customers pleasing.

POWER PLANT ENGINEERING September 1932

Armour Installs Modern Boiler at West Fargo, N. D.



With growing demand for steam and limited space available, the boiler unit selected is designed with water cooled furnace walls and is fired with pulverized coal. Two pulverizers and two burners, placed one above the other, permit wide variation in load on boiler designed for normal load of 60,000 lb. steam per hour. With a full complement of instruments and unique arrangement of power units high operating efficiencies are assured.

By H. K. BLANNING
Engineer, Armour & Co.

IN THE EARLY PART of 1931 it became evident that the steam generating capacity of the Armour & Co. abattoir at West Fargo, N. D., would have to be increased. The existing boiler room equipment installed by the coöperative company which built the plant, was out of date and because of its age was inefficient and expensive to maintain when operated at the required peak loads. The lack of standby equipment and the steam demand necessitating operating both boilers almost continuously, gave little opportunity for repairing.

In the original boiler plant were two 300-hp. Murray horizontal water-tube boilers, fired by hand. Hand-firing was abandoned two years ago when automatic over-feed stokers were installed. This gave increased capacity and efficiency but, because of restricted combustion space and the necessity of forcing the boilers to take care of increasing loads, the stokers were found to be insufficient for the work required and stoker maintenance costs became a heavy burden.

Study of the plant steam requirements as existing at present and which might be encountered in the near future, showed that present maximum requirements would normally be about 50,000 lb. of steam per hour, and the near future maximum demand around 60,000 lb. of steam per hour. The plant normally carries 150 lb. steam pressure and in consideration of future possibilities, it was decided that 250 lb. maximum steam pressure would give the best returns on any investment that might be made in extraction or back pressure electric power generating apparatus. Consideration is now being given to the savings that will result with the installation of a 250-lb. throttle pressure turbo-generator operating on 80 lb. back pressure to furnish process steam.

Choice of Equipment Governed by Fuel Available

Fuel used was West Virginia splint screenings shipped from the docks at Duluth. A study of fuel markets indicated, however, some possibility of Wyoming coal, Wyoming oil, North Dakota lignite, Southern Illinois coal or Chicago oil becoming available at competitive prices. Because of the extremely wide variation in the burning characteristics of these different fuels that might become available, it was decided after some study that the only fuel burning equipment or furnace that would adequately take care of this wide range of fuel would be pulverized fuel equipment and a water cooled furnace.

Space between the two existing boilers and the concrete stack serving them was the only site available at reasonable cost. It gave an area of only 63½ by 29½ ft. for the entire unit and auxiliaries. In order to assist in draft for the existing boilers and also to prepare a way for dismantlement of the breeching from the old boilers to the existing concrete stack, about one year ago a steel stack was erected on a gallows frame at the rear end of the two existing boilers. Because of the disadvantages in the old boiler room incident to ash removal and water seepage, it was decided to maintain the new boiler room floor at grade level. It was also decided that no basement would be provided, hence the new boiler would have a flat bottom refractory furnace floor with provision for ash removal through doors in the front and rear.

Features of Boiler Design

Work was begun on the installation of this third unit in the fall of 1931 and the unit was fired up and put in service the middle of January, 1932. Steel and

brick construction were used in the boiler house addition. The height is 43 ft. under the roof. The steam generating unit selected is a bent-tube, 4-drum type of boiler, 24 tubes wide, with the mud drum set 15 ft. over the floor. It contains 6150 sq. ft. of heating surface, exclusive of water wall areas. A slag screen is provided in the first row of the first bank of boiler tubes by a tube spacing 12 in. wide. The boiler is designed for an ultimate maximum working pressure of 250 lb. but will operate at 150 lb. gage pressure until later changes are made in the motive power equipment. No superheater was installed but provision was made for this later addition when the operating steam pressure is raised for power generation.

Practically the entire furnace wall is water cooled. This water cooling consists of bare 4 in. tubes on 9 in. centers. The rear wall contains 190 sq. ft. of projected area consisting of 16 tubes. Each side wall consists of 20 tubes with a total area of 483 sq. ft. The inlet and outlet headers of the side water wall tubes are on 12 ft. centers. The front furnace wall over the burners and the arch are water cooled, consisting of 15 tubes with a total of 250 sq. ft. The total area of water cooled surface in the furnace walls is 923 sq. ft. The bottom headers of the side wall tubes are 24 in. above the floor.

Furnace volume is 3700 cu. ft. making a maximum heat liberation of 20,000 B.t.u. per cu. ft. per hour at maximum capacity of 60,000 lb. of steam per hour.

Price of fuel at this plant is relatively high so it was found that an air preheater would pay for itself in a relatively short time and in addition provide the necessary heat to the pulverizers to prevent possible trouble in their operation due to the moisture in the coal. A vertical tube type preheater was therefore installed. This preheater is arranged in such a fashion that it forms in effect the rear wall of the boiler and in this way conserving radiation losses and reducing brick work cost by making the preheater casing integral with the boiler setting. The preheater contains 16 rows of 2½ in. tubes 26 ft. long, arranged 27 tubes to a row. The total heating surface provided is 7350 sq. ft. The flue gas passes through the tubes from top to bottom and the air around the tubes from bottom to top.

Draft Equipment Provided

The new boiler was connected to the existing reinforced concrete stack, 6 ft. diameter by 125 ft. high, that formerly served the old boilers. Due to the capacity required of this new unit, together with the additional resistance interposed by the air preheater, it is found that an induced draft fan was necessary. A bypass damper was provided around the air preheater on the gas side to take advantage of possible power saving by shutting down the induced draft fan at times of extremely low capacity, such as on Sundays, even at a sacrifice of air preheat. As power is a relatively expensive item in this particular locality, a two-speed, pole-changing motor was purchased for the induced draft fan drive. The induced draft fan has a capacity at full speed of 50,000 cu. ft. per minute at 400 deg. F. and 5 in. total static pressure. At ¾ speed it has a

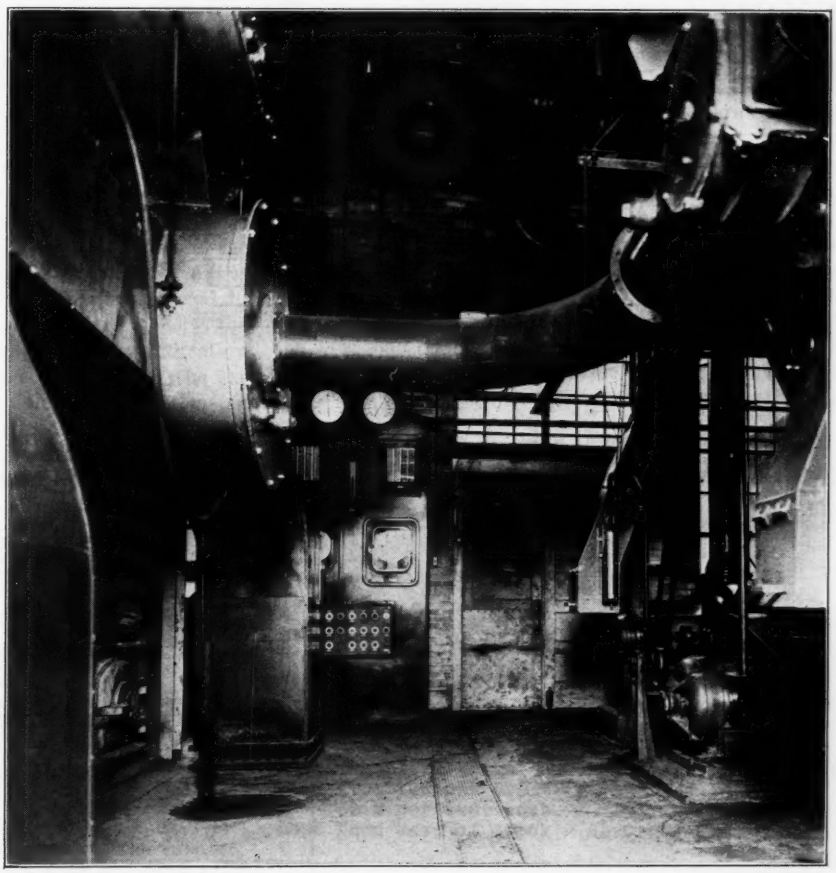


FIG. 1. FIRING AISLE

From this location, the attendant, through instruments and hand control devices may have complete knowledge of conditions and control of the unit.

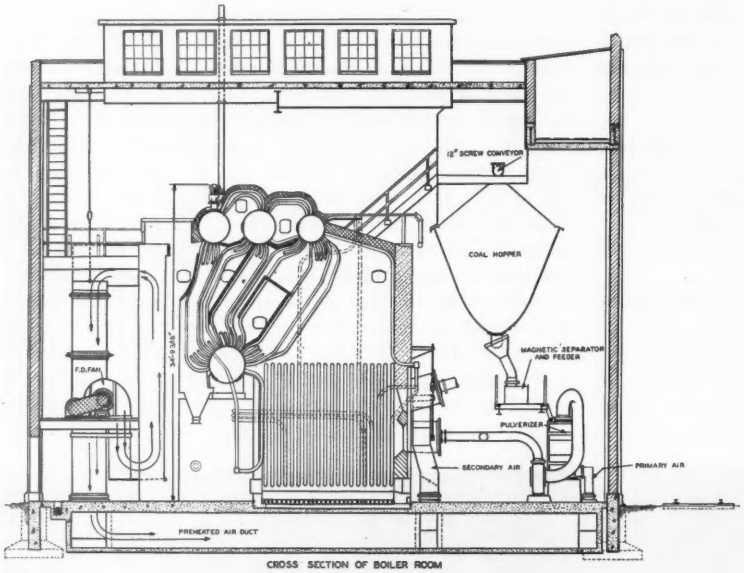
capacity of 30,000 cu. ft. per minute at 400 deg. F. and 3.5 in. total static pressure. Motor capacity at the two speeds is respectively 60 and 30 hp.

Arrangement was also made for two-speed pole-changing drive for the forced draft fan. At full speed it has a capacity of 20,000 cu. ft. of free air per minute at 6.5 in. static pressure and 70 deg. F. At ¾ speed, it has a capacity of 14,000 cu. ft. per minute at 70 deg. F. and 4 in. total static pressure. It is driven by a two-speed motor of 30 and 15 hp. respectively.

Fuel Handling and Firing

Coal is unloaded in the old pit and shoveled into a screen hopper arrangement from which it is transferred to a single chain bucket elevator approximately 53 ft. high by means of a 12 in. screw conveyor operating at 50 r.p.m. From the discharge of this bucket elevator, it is distributed by means of another 12 in. screw conveyor operating at 65 r.p.m. through two gates to a 50-ton capacity, parabolic bottom, steel bunker provided in the front of the boiler. The entire system of coal handling is driven by one 5-hp. motor.

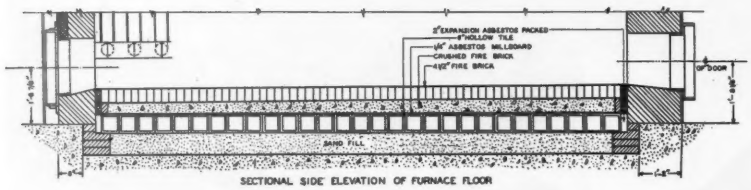
Firing equipment consists of two Whiting table roll pulverizers, each with a normal capacity of 6000 lb. of fuel per hour when supplied with primary air at a temperature of not less than 350 deg. To provide flexibility of heat balance and to insure having at least one pulverizer available regardless of the electric power avail-



CROSS SECTION OF BOILER ROOM

FIG. 2. PLANT SECTION

Boiler Room without basement necessitated special ventilated furnace floor and unusual preheated air duct. Burner arrangement and furnace completely surrounded by water walls are interesting features.



SECTIONAL SIDE ELEVATION OF FURNACE FLOOR

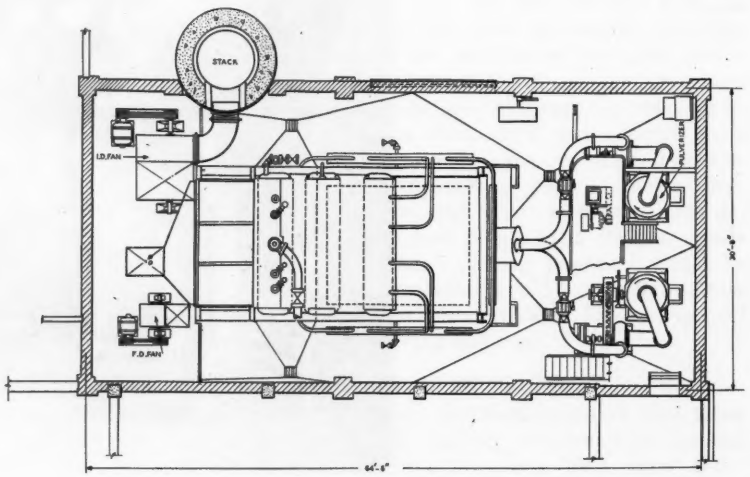


FIG. 3. PLAN OF BOILER AND AUXILIARIES

Space limitations dictated engineering features of the unit, choice of equipment and location of auxiliary equipment.

ability, one of the mills is driven by a 50-hp. non-condensing 1800 r.p.m. turbine and the other by a motor. The turbine drives the mill through a "V" belt from the shaft of the direct driven pulverizer exhauster. On the motor driven mill, a separate 1800 r.p.m. direct driven motor drives the exhauster. The drive of the motor driven mill is through V belt pulleys. A clutch is provided on the drive shaft of the turbine driven mill for starting or stopping independently of the exhauster. The feeders are on a platform above and in front of the mills directly under the coal bunker.

Coal leaves the bunker directly overhead and passes through the hopper to a variable speed belt, controlled by a P-V drive of which the driving pulley is magnetic for the separation of tramp iron. The tramp iron is deposited in a chute terminating at the operating floor. The coal discharges from the end of the feeder through a rubber hose into the mill. Each mill is equipped with four rollers.

Combustion air is taken from the room and delivered to the bottom of the preheater, circulating around the tubes and leaving the preheater at the top. From the top of the preheater, a duct carries the preheated air to the floor in the rear of the boiler where a reinforced concrete duct in the floor conveys the preheated air from the rear to the front of the boiler. The underground preheated air duct was provided to save space that ordinarily would be occupied by relatively large steel ducts. At the front of the boiler, the concrete duct divides, one branch carrying the secondary air to the burners and the other conveying preheated primary air to the pulverizers. Some 15 to 20 per cent of the total air requirement is used as primary air. Copper expansion joints are provided in the concrete duct and the top is insulated with 2½ in. of alumina block insulation.

Each of the pulverizer foundations is insulated from surrounding concrete by 1½ in. of cork to prevent mill vibrations being carried to adjacent structures.

Each mill air duct is provided with dampers to allow for cold room air, preheated air or both being admitted to the mill as primary air. Each mill is also provided with a differential draft gage to determine the differential across the mill, hence the coal loading of the mill when it is in operation. The motor driven mill is provided with an indicating wattmeter to show the power input to the motor driving it as an indication of the loading of the mill. In the discharge of the exhauster fan of each mill, an indicating thermometer is provided to secure the temperature of the coal-air stream mixture leaving the mills. Openings are also provided to secure samples of the pulverized fuel. A coal valve is installed in the discharge of each exhauster to prevent a possible back-flare from the furnace setting fire to coal dust in the piping when either of the mills is out of service.

Two burners are provided, one for each mill. These are of the turbulent type and located one above the other on the center line of the furnace. The lower burner center line is 7 ft. above the outside floor and the upper burner 4 ft. 6 in. higher. The upper burner is inclined downward at an angle of 15 deg. with the horizontal in order that the direct flame impingement, if any, will hit the rear wall of the furnace. The secondary air ducts connecting the floor ducts with the burner are located at each front corner of the furnace,

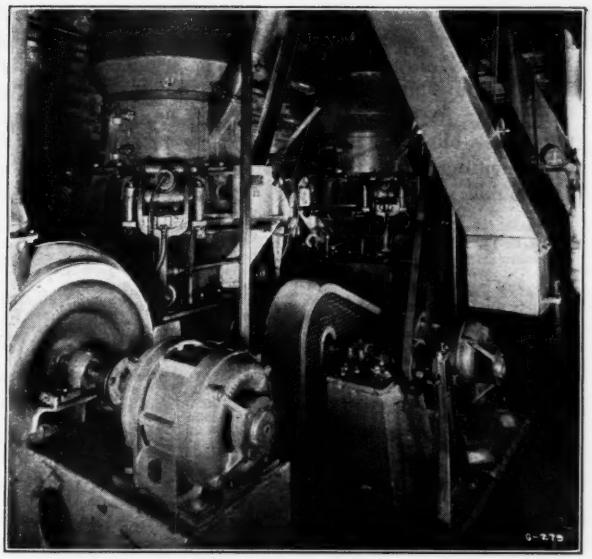


FIG. 4. TWO TABLE ROLLER PULVERIZERS SERVING BOILER IN ARMOUR PLANT

sloping over toward the burners after reaching head room height to provide for a clear space for ash removal and furnace observation directly under the burners. Dampers are provided in these ducts for the control of the secondary air.

Draft Regulation

A furnace draft regulator controls the boiler outlet damper so as to maintain a constant draft in the furnace. In order to make certain that the uptake damper always operates at a point in its arc where most accurate regulation can be secured, louvers were provided at the inlet of the induced draft fan. These are manually adjusted to maintain the furnace draft regulator and the damper in regulating range at low rating and at high rating, immediately after changing from low speed to high speed on the induced draft fan.

Of particular interest is the provision made for expansion of the water screen drain and boiler blowoff piping. As no basement is provided, the usual arrangement of blowoff piping passing through the floor into the basement providing for adequate expansion facilities, it was necessary to provide for expansion of the boiler and piping and the movement of water wall head-

TABLE I. CARBON IN FLUE DUST SAMPLE FROM HOPPERS UNDER MUD DRUM

Screen Mesh	Per cent Through	Per cent Comb. in dust passing through
200	40.8	63.0
150	42.9	63.3
100	48.9	64.5
65	66.8	65.7
48	86.4	68.5
35	91.4	69.4
28	98.7	70.5
28	Retained	89.0

Total sample average - 71.2 per cent combustible
Dust from induced draft fan suction duct - 69.2 per cent comb.
Dust from base of stack - 62.0 per cent comb.

ers by other means. The water wall drain and boiler blowoff piping are connected to a common header laid in a shallow concrete trench in the boiler room operating floor. Expansion is taken care of by three flexible pipe ball joints in each one of the drain connections and the boiler blowoff. These are giving good satisfaction by providing full expansion facilities and have given no trouble with leakage. The water screen drain connections are 1½ in. and the boiler blowoff 2½ in.

TABLE II. BOILER AND AIR HEATER GUARANTEE DATA

Pounds of steam per hour	30,000	40,000	50,000	60,000
Steam pressure - pounds per sq. in.	165	165	165	165
Percent CO_2 leaving boiler	13	13	13	13
Percent CO leaving boiler	0	0	0	0
Temp. flue gas leaving boiler deg.F.	520	560	610	665
Temp. flue gas leaving A. H. deg.F.	299	331	365	401
Flue gas temp. drop deg.F.	221	229	245	264
Temp. air entering preheater deg.F.	80	80	80	80
Temp. air leaving preheater deg.F.	355	365	385	409
Air temp. increase deg.F.	275	285	305	329
Temp. of boiler feedwater deg.F.	200	200	200	200
Eff. of boiler and furnace per cent	80.1	79.0	77.6	76.1
Eff. of boiler A.H.and furnace per cent	86.2	85.3	84.4	83.4
Draft loss through boiler in.H_2O	0.26	0.55	0.92	1.40
Draft loss through A.H. in.H_2O	0.40	0.71	1.12	1.65
Air resistance through A.H. in.H_2O	0.23	0.41	0.64	0.95

Based on West Virginia Coal of 12,512 B.t.u. per lb., 8.46 per cent ash and 4.2 per cent moisture

In addition to the usual boiler accessories a connection was made to provide for continuous boiler blowoff through ¼ in. diameter fixed orifice from the middle drum of the boiler. This boiler blowdown water is passed through a coil in a heater furnishing hot water for process, after which it is discharged to the sewer.

Furnace Construction

In order to provide sufficient protection to the concrete against heat, the concrete foundation of the boilers was depressed 10 in. below grade level in the area immediately under the furnace floor. This 10 in. space was then filled with 7 in. of sand on top of which was placed 6 in. hollow tile; then a ¼ in. asbestos board on top of which was then placed 4½ in. crushed fire brick and the top finished off with 4½ in. fire brick on edge. Suitable provision for expansion was made where the brick work of the floor butts against the side walls. The hollow tile is open to air circulation from side to side of the furnace. The design has worked out satisfactorily as at no time has there been any evidence of overheating of the furnace floor underneath the tile. The top of the furnace floor is 12½ in. higher than the outside boiler room floor.

TABLE III. ACTUAL BOILER OPERATION RESULTS

Pounds of steam per hour	34,000	42,000
Air flow	34,000	42,000
Meter - CO_2 per cent	14.9	14.5
Furnace draft in.H_2O	0.16	0.20
Boiler outlet draft in.H_2O	0.38	0.55
Preheater air inlet pressure in.H_2O	4.2	4.0
Preheater air outlet pressure in.H_2O	4.1	3.6
A.H.and duct draft loss	0.20	0.25
Temp.flue gas leaving boiler deg.F.	480	480
Temp.flue gas leaving A.H. deg.F.	280	290
Flue gas temp.drop deg. F.	200	190
Temp. air entering A.H. deg.F.	85°	85°
Temp. air leaving A.H. deg.F.	345	350
Air temp. increase deg.F.	260	265
Mill differential in.H_2O	4.7	5.8
Coal-air stream temp. deg.F.	146	134
Secondary air press. in.H_2O	0.30	0.65
Kw.Input to Mill	14.0	17.0
Kw. per ton to Mill	8.2	8.1
Steam pressure lb.per sq.in.	147	135
Outside air temp.	Minus 2	Minus 2

Steel casing ⅛ in. thick completely surrounds the boiler. All of the brick work is of sectionally supported construction, either insulated or natural draft air cooled. All of the sectionally supported brick work back of the water cooled areas is 9 in. thick and provided with 3 in. of plastic insulation. The upper front side walls and the lower front wall around the region of the burners and extending up to the bottom header of the front water cooling area is of sectionally supported, natural draft air cooled construction and provided with ½ in. of plastic insulation and 9 in. refractory. The upper rear side walls are sectionally supported and insulated with 3 in. of plastic cement, but are not air cooled.

Interlocking Electric Circuits

Complete electrical sequential interlocking push button hand control was provided for starting and stopping of the boiler auxiliaries and changing the speed of the fans. These push buttons and indicating lights for each one of the operations are mounted on the boiler instrument panel. The interlock control is arranged in such a way that the induced draft fan, the forced draft fan, the exhaust fan and the pulverizer driving motor must be started in the order named. Similarly, the induced and forced draft fans must be started before the automatic trip of the turbine driving the turbine driven mill and exhauster can be released.

For insulating the air preheater, hot forced draft air duct and the induced draft fan duct 1 in. of 85 per cent magnesia is used which is held in place by 5/16 in. studs welded to the duct and perforated steel strips. The whole is dressed with a hard finish insulating cement. The entire duct work is insulated with the exception of the bellows type expansion joints provided in the ducts. The hot gas ducts, after leaving the preheater, were insulated in order to maintain more comfortable temperatures in the boiler room.

Difficulties Encountered in Starting

When starting up the unit, it was found impossible to ignite the pulverized fuel with the usual portable blow torch provided. This difficulty was doubtless emphasized by reason of the extreme low temperature of the coal being used and the lack of preheated air for the mills. In order to secure a large enough flame to insure ignition, a 300-gal. oil tank was installed at an elevation of 15 ft. over the floor and piping connections made to a small 50-gal. per hour gear type pump, driven by ¼-hp. motor. The discharge of the pump was then piped direct to a flexible pressure hose and the oil atomized in an atomizing tip screwed on to the end of a piece of ¼-in. pipe. A pressure of 110 lb. was maintained on the atomizing tip by means of an automatic bleed-off valve on the discharge of the pump. One tip consumes about 10 gal. oil per hour. Distillate was used for fuel. This type of lighting torch was found to be successful as it gave an intense flame of sufficient spread and length to insure positive ignition of the fuel. It also did away with the necessity of interrupting operations to refill a portable tank with oil and to pump the tank up with compressed air. The lighting torch was inserted in the lighting hole of the burner and an asbestos wicking hand torch placed alongside it to

Boiler Equipment added to Armour & Co. Plant

Boiler—Babcock & Wilcox Co., Stirling Class XXI, No. 24. 6150 sq. ft. boiler htg. surface. Water walls 923 sq. ft. 250 lb. pres. Furnace volume 3700 cu. ft. 4 drums, 24 tubes wide. Heat release 20,000 B.t.u. per cu. ft. per hr. 60,000 lb. steam per hr. Gas velocities around baffles 32 to 62 ft. per sec.

BOILER FITTINGS

Water Column—Reliance Gauge Column Co., Hi and low alarm.
Non-return Valve—Golden-Anderson Valve Specialty Co., plain cushioned.
Feedwater Level Regulator—The Stets Co., closed float type.
Blowoff Valves—Everlasting Valve Co., tandem.
Safety Valves—Consolidated Ashcraft Hancock Co.
Drum Head Stop and Check—Edward Valve & Mfg. Co.
Air Preheater—Babcock & Wilcox Co., 7350 sq. ft. tube type.
Water Walls—Fuller Lehigh Co., plain tube, 923 sq. ft.
Water Wall Drain Valves—Edward Valve & Mfg. Co., tandem.
Baffles—Power Plant Efficiency Co., interlocking.
Suspended Walls and Casing—M. H. Detrick Co.
Furnace Draft Regulator—Carrick Eng. Co.
Pulverizers—2, Whiting Corp., table roll type, 6000 lb. per hr. each, 350 deg. primary air; drive, one 50-hp. motor, one turbine through exhauster shaft and V belt.
Exhausters—Clarage Fan Co.
Pulverizer Turbine—The Terry Steam Turbine Co.
Fan, Forced Draft—Buffalo Forge Co., 20,000 c.f.m., 6.5 in. pres., 70 deg. F. at full speed; 14,000 c.f.m., 4 in. pres., 70 deg. F. at ¾ speed; two-speed, pole changing motor drive, 30 and 15 hp.
Fan, Induced Draft—Buffalo Forge Co., 50,000 c.f.m., 5 in. pres. 400 deg. F. at full speed, 30,000 c.f.m. 3.5 in. pres. 400 deg. F. at ¾ speed; two-speed motor drive, 60 and 30 hp.
Fan Drives—Allis-Chalmers Mfg. Co., Texrope.
Motors—Allis-Chalmers Mfg. Co., 220-v., 3 phase.
Push-button Control—Allen Bradley Co.
Building Steel Ducts, Platforms, Etc.—Fargo Foundry Co.
Soot Blowers—Diamond Power Specialty Co., 5 elements, 2 Dialoy, 1 calorized steel, 2 plain; automatic, positive closing type.
Main Steam Piping—Midwest Piping & Supply Co. and Crane Co., welded, Van Stone flanges.
Feedwater Piping—Midwest Piping & Supply Co., welded, Van Stone flanges.
CO_2 Meter—Hays Instrument Co.
Boiler Meter—Bailey Meter Co.
Instrument Panel—Bailey Meter Co.
Recording Thermometers—Bailey Meter Co.
Feedwater and Steam Pressure Ind. Gages—Bailey Meter Co.
Indicating Draft and Air Pressure Gages—Louis M. Ellison Co.
Remote Boiler Water Level Gage—T. W. McNeill.
Pipe and Duct Insulation—Johns-Manville Corp.
Coal Handling Equipment—Link-Belt Co.
Blowoff Piping Ball Joints—Barco Mfg. Co.
Feedwater Globe and Check Valves—Edward Valve & Mfg. Co.
Feedwater and Steam Gate Valves—Reading-Pratt & Cady Co.

furnish ignition for the atomizing torch successfully.

It was also found on lighting off the furnace, that the usual ignition hole provided in the burners by a pipe running parallel to the axis of the burner was not as satisfactory as a hole cut in the face of the boiler wall adjacent to the burners and directed in such a way that ignition flame went directly across the burner face.

Several months' operation has demonstrated that too much induced draft fan capacity was provided. It was found that the boiler could be satisfactorily operated with a lower excess air than that originally planned and that the draft loss through the boiler, air preheater and duct work was not as high as anticipated. These factors combined to give an over-capacity in the induced draft fan and arrangements are now being made for changing the sheave diameters of the tex-rope drive on this fan to reduce fan speed to nearly exact requirements.

In the original installation the coal left the bunker at the bottom through two 14 by 14 in. universal coal gates, connected to spouts 13 in. inside diameter through which the coal was discharged direct to the belt feeder. It was found that the coal would not feed through these gates and spouts satisfactorily, possibly because of the frozen wet condition of the coal and its fineness. In any event, it was necessary during times of regular operation to keep a man stationed at this point to keep the coal moving. To overcome this, a hopper arrangement of a general form of an inverted frustum of a pyramid was installed, connecting the bunker to each of these feeders. The opening of this hopper into the bunker is 3 ft. 6 in. by 4 ft.

West Virginia splint and Pocahontas screenings have been used continuously as fuel since the installation was started up. These fuels normally have a fusion temperature of anywhere from 2500 to 2600 deg., consequently, no difficulty has been experienced with slag.

Tests were made of the per cent combustible and the fineness of this flue dust, particularly that collected from the hopper underneath the mud drum. The results of tests made are given in Table No. I, which shows the per cent combustible in dust of each size as it was screened, as well as average total per cent combustible in the dust as a whole.

Preliminary test showed a maximum of 0.9 per cent by weight of the total fuel fired settled in the dust hoppers and ducts as flue dust or coke dust. This is all refired in the furnace. Indications are that a negligible amount of combustible escapes up the stack.

Boiler water treatment consists essentially of straight internal treatment with soda ash and sodium aluminate. The raw water taken from the Cheyenne River shows a hardness of around 22 g.p.g. and a methyl orange alkalinity of 20 g.p.g. equivalent calcium carbonate. It is filtered to remove suspended solids. The boiler water hardness is maintained below 1.0 gr. per gal. with a phenolpthalein alkalinity of 15 to 20 g.p.g. and a methyl orange alkalinity of 20 to 30 g.p.g. Total boiler water concentrations of dissolved and suspended solids are normally maintained at 250 g.p.g. but at times the total solids have gone up to 400 to 450 g.p.g. About 25 to 35 per cent of the total solids is suspended matter. To date, there has been no evidence of scale accumulation in any of the water wall tubes of the furnace.

Table No. II shows some typical readings of draft drops, temperatures, etc., of the unit. Operating records indicate that, with the turbine driven pulverizer shut down and the entire steam load being generated by the motor driven mill, the total boiler room auxiliary power and light consumption including the coal handling equipment varies from 1 to 1½-kw-hr. per 1000 lb. of steam generated. It is anticipated that this figure will be reduced appreciably after the induced draft fan speed is reduced to that actually required.

Normally, one pulverizer will take care of the entire fuel requirements. The load is swung from the turbine driven to the motor mill or vice versa to suit the local plant demands for exhaust steam. At extreme low loads it has been arranged that one or more rolls of the pulverizer in service can be lifted off the table of the pulverizer in order to secure lower power consumption.

Pulverization of the coal has been satisfactory. The tests made on a standard Tyler machine, using the standard screens show that for normal loads the fineness shows greater than 99 per cent through a 48 mesh and 69 to 82 per cent through a 200 mesh. The fineness varies according to the moisture or frozen condition of the coal, as well as the rate of steam generation. Under normal operation, 100 per cent of the air supply to the mills is preheated. The temperature of the coal and air stream mixture leaving the mill varies from 140 to 190 deg. F., depending on the preheated air and coal temperatures, and moisture in the coal.

POWER PLANT ENGINEERING September 1932

Capacity Determination for Variable Pressure Steam Accumulators

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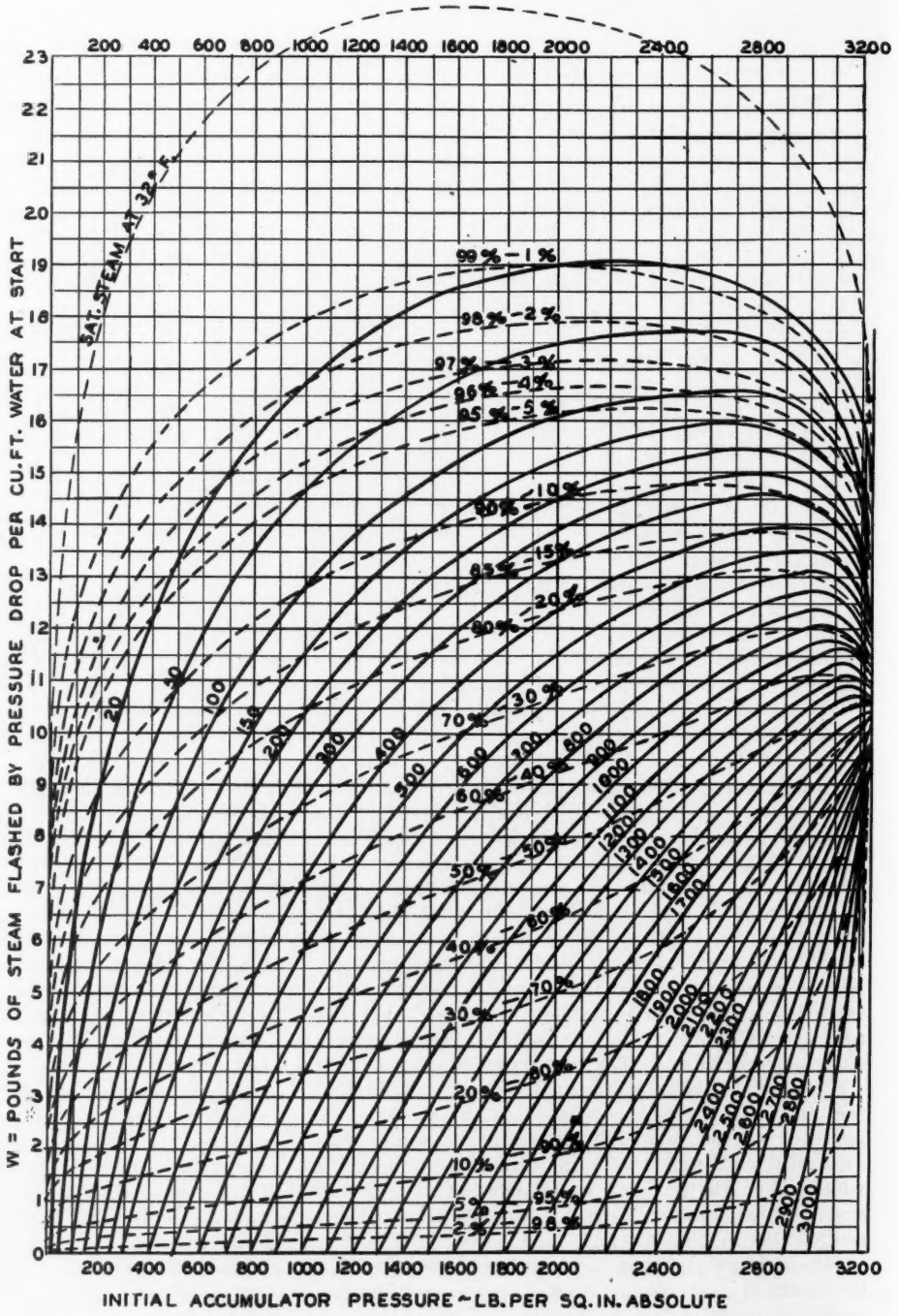
W = POUNDS OF STEAM FLASHED BY PRESSURE DROP PER CU.FT. WATER AT START
INITIAL ACCUMULATOR PRESSURE ~ LB. PER SQ. IN. ABSOLUTE
SAT. STEAM AT 32° F.
99% - 1%
98% - 2%
97% - 3%
95% - 5%
90% - 10%
85% - 15%
80% - 20%
70% - 30%
60% - 40%
50% - 50%
40% - 60%
30% - 70%
20% - 80%
10% - 90%
5% - 95%
2% - 98%

FIG. 1
RELATION OF INITIAL AND FINAL PRESSURES TO VOLUME OF STEAM ACCUMULATORS FOR VARIABLE PRESSURE DISCHARGE

THERMAL STORAGE has the following functions: To smooth out the rate of flow of steam from the boiler, thus giving more constant rate of firing and reducing priming caused by sudden steam demands, also permitting use of boilers with smaller water volume such as electric steam generators and series type water-tube boilers; to increase steam output during peak load by condensing high-pressure steam in the accumulator during low-load periods and supplying low-pressure steam during peak demands; to act as standby source of energy in emergency or planned shutdown; to save steam otherwise wasted to atmosphere.

For the Ruths accumulator, the first commercial installation was in 1918, over 500 plants now being equipped. The largest outfit is 16 ft. diam. by 76 ft. long of 14,500 cu. ft. capacity and the smallest is 4 ft. diam. by 5 ft. long of 60 cu. ft. Maximum charging pressure in Europe is 350 lb. and in America 200 lb. With proper lagging, heat loss is small, 0.2 B.t.u. per degree F. per sq. ft. per hr. or 60 B.t.u. per sq. ft. per hr. for 300 deg. temperature difference between steam and atmosphere.

High-Pressure Plants

With the trend toward higher pressures and temperatures to get better thermodynamic availability of heat in the steam, comes the requirement for smaller boiler steam drums, or even no drums at all. This results in less water storage capacity in the boiler, hence loss of heat accumulator action in the boiler itself.

For the high-pressure phase of the steam cycle the accumulator vessel is subject to the same structural limitations as is the boiler. But in compound industrial steam cycles it is quite possible that steam be generated at a constant rate in a high-pressure boiler of the series type and be passed through a constant-load, base-load turbine generator which in turn may exhaust into the lower pressure system. A Ruths accumulator would provide for the variations in the steam demands at the lower pressures in the plant caused by variable process steam demands and the variable steam supply to a variable-load, low-pressure turbine generator operating in parallel with the high-pressure, constant-load machine. Such an arrangement would provide a steady boiler load and allow the plant to obtain the advantages of the high-pressure steam cycle.

Calculation of the Size of a Ruths Accumulator

The size of an accumulator, or better the storage volume, depends upon the initial and final working pressure limits and the weight of steam which it is required to discharge between these pressure limits. The economics of the installation require a careful determination of the accumulator size, hence it is quite important that the relation between the weight of steam to be discharged, per unit of water volume under the charged pressure, for the given initial and the final pressures be known. Mathematical relations concerning the Ruths accumulator storage and discharge process have been presented by Marks, Stodola and Ruths in the form of equations, but none of them seem to express simply the relation sought. The author, therefore, suggests the following solution to the problem:

During the discharge process of the steam accumulator the states of the internal water and steam are

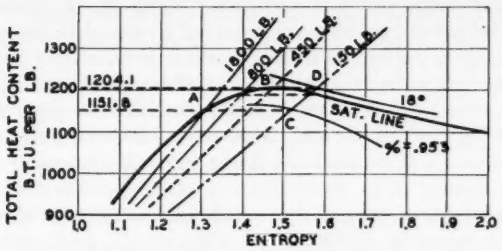

FIG. 2. SEQUENCE OF STEAM WETNESS WITH FALLING PRESSURE IN ACCUMULATOR, DELIVERY AT CONSTANT PRESSURE

continually changing, resulting in a number of variables which are pressure, temperature, heat content, entropy, weights of water and steam or vapor in the vessel and of the steam discharged from the start of the process.

Consider the accumulator vessel to be charged and under the initial pressure p_1; that the discharge process includes the vaporization of a portion of the accumulator's water into steam and the further expansion of this steam through the discharge line reducing valve to the final pressure p_2; that this process provides r lb. of steam at pressure p_2 per pound of water in the accumulator at pressure p_1, then the total energy contained in a pound of water before discharge starts must equal the energy left in that part of the pound remaining after the discharge plus the energy carried away with the steam discharged.

If h_1 be heat of the liquid in the original pound of water at initial pressure p_1 and h_2 the heat of liquid at final pressure p_2, also l_2 be latent heat of vaporization at pressure p_2, then $h_1 = rl_2 + h_2$; $r = (h_1 - h_2) \div l_2$. To change to pounds of steam per cubic foot of water at charging pressure, W, multiply by d_1, the density of water at p_1, and $W = rd_1 = d_1 (h_1 - h_2) \div l_2$.

This equation was used in plotting the curves presented in the chart which illustrates graphically the values of W at the left in terms of the initial pressure at the bottom and final pressures, the full curved lines in the Ruths steam accumulator, the range of initial pressure being 0 to 3226 lb. per sq. in. absolute, final pressures from 20 lb. to 3000 lb. abs. Lines of constant percentage pressure drop, dotted, are also given to facilitate the determination of the accumulator effect in drum type boilers with various allowable pressure fluctuations, the index figures showing percentage of pressure drop to initial pressure, also percentage of final pressure to initial.

Volume occupied by the water when an accumulator is charged is about 90 per cent of the total vessel volume. The heat energy storage capacity of the vapor in the remaining 10 per cent volume has been neglected in plotting the curves, the error caused by this method reaching a maximum when the initial or charged pressure is the critical pressure, where steam and water are the same density, of about 10 per cent, if the volume factor of 90 per cent is used. At an initial pressure of 3000 lb. per sq. in. abs. the error is within 5 per cent and, for the usual pressure ranges, the error due to the neglect of the vapor heat energy storage is negligible.

Utility of the curves may be illustrated by the following example: Assume that a plant survey indicated that a certain process steam load was responsible for

boiler room troubles and that 90,000 lb. of steam at 20 lb. per sq. in. abs. are required to complete the process. It is desired to install a steam accumulator to furnish this steam independent of the boilers, during the time the process steam is being used. Boiler pressure is 250 lb. per sq. in. abs. The chart indicates that 10 lb. of steam will be discharged per cubic foot of water with a pressure drop from 250 lb. to 20 lb. To discharge 90,000 lb. of steam, the water volume of the accumulator must be 90,000/10 = 9000 cu. ft. and since the vessel should be but 90 per cent filled when charged, the total internal volume of the accumulator must be 9000/0.9 = 10,000 cu. ft. Economic considerations of design will dictate the proper diameter and length to obtain the required volume.

Further inspection of the chart will bring out many characteristics of the steam accumulator. For a 10 per cent pressure drop from the initial pressure in the accumulator, the value of W rises with the initial pressure. This is true but to varying degree for all percentages of pressure drop up to 50. Above that, a reverse effect occurs, starting at 3000 lb. initial pressure for 60 per cent drop and moving downward to 1800 lb. for 99 per cent drop.

For a drop of 100 lb. per sq. in. from the initial to the final pressure, W decreases from initial pressure of 100 lb. to initial pressure of about 1400 lb., then remains nearly constant to 2000 lb., then increases. Like effect will be found for any other constant value of pressure drop.

Another factor oftentimes determines the size of the accumulator. The rate of discharge from the accumulator must be limited to a value which will insure dry and saturated steam delivery from the discharge connection. This is accomplished by installing a flow nozzle in the discharge connection and so proportioning its throat area that a maximum rate of discharge of 1300 cu. ft. of water per sq. ft. of evaporating surface per hour is reached when the steam velocity in the throat of the flow nozzle reaches the critical velocity. To meet some steam demands the vessel must be designed with this limiting factor in mind. In the event of a serious rupture of the discharge line, the flow nozzle will limit the discharge rate from the accumulator to the safe values.

Delay in adoption of the accumulator may be attributed to the following causes: For high pressure, design of the vessel is limited by the same factors as boiler drum design; condensation of high-pressure steam to be discharged at lower pressure increases the unavailability of the heat content but the loss is comparatively small and for steam used in process work or heating is zero; an accumulator delivers saturated steam which is undesirable for use in steam turbines, if expansion in the turbine will reduce steam quality to 90 per cent or less saturation.

Low-Pressure Turbine Supply

If delivery be direct to the turbine at varying pressure, the steam supplied will always be saturated. But if initial pressure in the accumulator be above 400 to 450 lb. abs. and discharge is through a reducing valve to a constant pressure less than 400 lb., steam discharged will contain a gradually decreasing percentage of moisture until accumulator pressure falls to 400 to 450 lb.; after that it will be slightly superheated, superheat being maximum for the 400 to 450 lb. range, then decreasing until accumulator pressure reaches its final discharge value. This is because the total heat content of saturated steam is a maximum at about 425 lb. abs. Figure 2 shows the sequence of conditions for initial pressure of 1800 lb. and final pressure 150 lb. At the start steam delivered is 95.3 per cent dry; at 800 lb. it is saturated, then becomes superheated until accumulator pressure falls to 150 lb.

Use of an accumulator in a high-pressure plant with reducing valve to supply a constant lower pressure requires, therefore, careful study of conditions.

Use for Superheated Steam

Superheated steam may be stored in the Ruths system by first passing the steam through an auxiliary chamber filled with cast-iron blocks which are eventually raised to the steam temperature, the steam then passing on to a conventional accumulator. During the discharge process, the steam reverses this path and recovers the energy stored in the cast-iron blocks to superheat it again on its way to the discharge connection. It may be quite possible to store the superheat energy in some other material whose mean specific heat is greater than that of cast-iron, or it may be possible in binary-cycle or in binary-reheat-cycle plants to superheat the accumulator discharge steam by means of the second fluid which may be mercury, diphenyloxide, or other material. Such an arrangement must provide a fairly constant total steam temperature, where the steam is to be used in turbines, in order to minimize expansion troubles.

For high-presure steam storage, it may prove economical to construct accumulators from small diameter unit vessels, arranging them in battery. These could be standardized for certain ranges of initial pressures, manufactured and stocked in large numbers. The design of the installation as to storage capacity would be flexible and the units could be located in otherwise dead space about the steam plant. Just what the dimensional and pressure limitations would be for economical installations under this plan will require lengthy study.

In spite of the development of stokers and automatic boiler controls, installation of a heavy shell accumulator may prove to be a better long-time investment than would another boiler to obtain peak load capacity, when the fixed, operating and maintenance costs of the two types of equipment are carefully evaluated and considered on an equitable basis.

Taxes of $210,000,000 paid in 1931 by electric utilities have, of course, been part of the cost to customers of electric current. If, however, utilities were government owned, so that no taxes were collectible from them, that amount would have to be raised by some other form of taxation on the public, to meet the demands of our inflated government activities. All evidence as to government operation points to a probable cost for service higher than that now existing, so that customers, under government ownership and operation, would pay as much as or more than at present for service and, in addition, would have the added expense of taxation in some form to make up for that lost in utility company taxes.

Operating Code Manual for Power Plants

Surface and Jet Condensers, Pumps and Air Compressors

TUBE LEAKAGE and air leakage of condensers impair power plant operation, the former because it contaminates the boiler feedwater and the latter because it reduces the vacuum.

Surface Condensers—Periodic Tests for Tube Leakage

Periodic tests should be made for leakage on surface condensers. There are several methods in general use.

While shutting down the turbine, a test should be made for leakage on the condenser, as follows:

1. Maintain as low a back pressure as possible in the steam space of the condenser.

2. With the suction valve of the wet pump closed (also the suction equalizing line when one is installed) note the rate at which water rises in the hotwell, deducting steam and water used for sealing. The rise of water in the hotwell under these conditions indicates a leakage of circulating water into the steam space.

3. Record in the daily log sheet the rate at which the water rises and the back pressure at that time.

4. When an additional chemical test is required, (a) take a one or two-gallon sample of circulating water while the hotwell is filling; (b) take a one or two-gallon sample of water in the hotwell immediately at the end of the test; (c) forward the samples to the laboratory for analysis.

Surface Condensers—Periodic Test for Air Leakage

1. Just before shutting down the turbine, close the suction valve to the air pumps and note time required for vacuum on condenser to drop one inch. This will give a measure of the air leakage. (Note: Back pressure should be watched continuously during operation. Appreciable change at any given load may indicate a leakage.)

Jet Condensers—Test for Air Leakage

Fill the condenser with water up to turbine glands, and if there are any leaks, stop them.

Starting Plunger Type Pumps

1. See that the exhaust valve is open.
2. Open drains on steam cylinder and exhaust line.
3. See that the discharge valve is open. (Note: If bypass is provided, pump should discharge back to the suction through bypass, when starting.)
4. Open the suction valve. (Note: Where a pump is being started in parallel with another already in operation, the danger, due to air binding of the latter, caused by the opening of the suction valve on the incoming pump, particularly where there is a suction head, can be overcome by starting the incoming pump slowly, establishing a vacuum on its suction side somewhat greater than that on the pump in operation before opening the suction valve. Then when the suction valve of the incoming pump is opened the operation of the pump already in operation will not be affected.)
5. See that the lubricator is working properly and oil all moving parts both before and after starting.
6. Open the throttle valve and start slowly.
7. Bring the pump to speed for desired pressure.
8. Close the drains.

Shutting Down Plunger Type Pumps

1. Close the throttle valve.
2. Close the exhaust valve.
3. Turn off the lubricator.
4. Close suction valve.
5. Close discharge valve.

Starting Synchronous Motor Driven Air Compressors

1. Close the suction valve.
2. Open bleeders on air cylinders and connections.
3. Open the water valves to the cooling jackets.
4. See that the oiling system is working properly, both before and after starting and do any necessary oiling previous to starting.
5. See that the discharge valve is closed.
6. Open the free exhaust valve on the discharge line.
7. Start the synchronous motor and bring to speed.
8. Open the discharge valve.
9. Close the free exhaust valve on the discharge line.
10. Open the suction valve.
11. Close all bleeder valves.
12. See that all control valves are working properly.

Shutting Down Motor Driven Synchronous Air Compressors

1. Stop the compressor.
2. Close the discharge valve.
3. Open the free exhaust valve on the discharge line.
4. Close the suction line.
5. Shut off the water supply to the cooling jacket.
6. Shut off the oiling system.

Starting Steam Driven Air Compressors

1. Open the exhaust valve.
2. See that the steam drain valves are open.
3. Open bleeders on air cylinders and connections.
4. See that the oiling system is working properly both before and after starting and do any necessary oiling previous to starting.
5. Open the water valves to the cooling jackets.
6. Latch the cut-out valve in the closed position.
7. Open the throttle slightly and run the machine slowly while heating up.
8. Gradually open the throttle wide, bringing the compressor to speed.
9. See that governor operates and holds speed constant.
10. Close the bleeder and drain valves.
11. Release the cut-out valves.
12. When working pressure is almost reached, open the air discharge valve.
13. See that the cut-out valves and the control valves are operating properly.

Shutting Down Steam Driven Air Compressors

1. Latch the cut-out valve closed.
2. Close the air discharge valve unless check valve is used.
3. Close the throttle valve.
4. Open the drain valves.
5. Shut off the water supply to the cooling jackets.
6. Shut off the oiling system after machine stops.
7. Shut off the lubricators.
8. The exhaust valve should be closed.

POWER PLANT ENGINEERING September 1932

The Boiler Room Today

DESIRE OF DESIGNER AND MANUFACTURERS TO INCREASE ECONOMY REVIEWED BY COMBUSTION ENGINEERING CORP. IN A SPECIAL REPORT TO POWER PLANT ENGINEERING

GREATER EFFORTS on the part of the purchaser and manufacturer are constantly being made to improve efficiency and economy in the utilization of heat. The manufacturer is more and more being taken into the confidence of the purchaser in a way that brings out all of the important factors influencing cost and performance. Adaptability to space limitations in existing plants and varying conditions throughout the country, such as grade and cost of fuel and the purity of water, are factors which influence variation in design.

Former practice of boiler room designers usually gave first consideration to the selection of a boiler which, when operating at a given per cent of rating, would carry the required load. After the boiler dimensions were determined, the furnace was fitted to the boiler. Some boilers of the sectional header type were installed 30 tubes wide and 14 tubes high, while for the same duty others were 21 tubes wide and 20 tubes high. Both boilers contained the same heating surface, but the latter was more efficient and probably cost 10 per cent less. It is possible, however, that this boiler was even less economical when considered as a complete unit, as the furnace design necessary to meet the boiler dimensions may have been insufficient. The same is true of bent tube boilers where the furnace width should be kept to the minimum required for good furnace design, as the drum cost is the major item and may amount to as much as 60 per cent of the total boiler cost. Of course, where boilers are operated with natural draft, freedom of design is restricted by the draft available.

FURNACE NOW CONSIDERED FIRST

Modern practice of boiler room designers gives first consideration to the furnace for all sizes of installations and all types of firing, so that an economical and efficient design may be obtained. For example, with pulverized coal firing, special attention is given to the required furnace volume which depends mainly on the ash fusion temperature of the coal. A further characteristic of modern design is the all but universal use of water cooled furnace walls which eliminate furnace maintenance and serve the equally or more important purpose of reducing the temperature of the gases to a point below the fusion temperature of the ash before their entrance into the boiler tube bank.

Next step is to select the type of boiler most suitable for the furnace design. At times, the shape of the furnace, which is governed by site limitations, character of fuel and operating conditions, will determine whether a sectional header or bent tube boiler is the more desirable. Under normal conditions, however, either type can be used to advantage, although it is generally conceded that the bent tube boiler is better adapted for the extremely large units.

Steam drums are the next item to be selected and the diameter is determined on the basis of steam volume and liberating surface depending upon the operating pressure and water conditions. In some cases where the manufacturing facilities limit the drum diameter, the expedient of installing an additional dry drum to obtain dry steam has been very successful. The number of steam drums used with a bent tube boiler depends upon conditions and is generally determined by the space available or by the purchaser's preference.

Average central station design is for a gross steam generating efficiency of 85 per cent which, with the present day fuel burning efficiency, corresponds to approximately 400 deg. final exit gas temperature. Various heating surfaces to reduce the furnace gas temperature to this point are usually made up of boiler, superheater, economizer and air preheater. Of these the superheater absorption is definitely fixed. The other three combined must absorb a fixed amount of heat. In their relative proportions, however, a great deal of flexibility in design exists. The designer's problem is to so adjust these proportions as to give the most economical assembly. Ordinarily, the air preheater is the first of the three surfaces to be determined and takes the heat range from about 700 deg. down to the 400 deg. final gas temperature. Secondly, an economizer is selected to raise the feedwater temperature to within 75 to 50 deg. fahr. of saturated steam temperature with a corresponding drop in gas temperature. Finally sufficient boiler surface is installed to absorb the balance of heat.

In some cases, such as with bent tube boilers, it is more economical to install as much boiler tube surface as the drums will permit, thus either eliminating the economizer or reducing its size. The boiler tube surface, up to the limiting possibilities of the drums, is the least expensive of all. The above outline of modern procedure in design shows that instead of selecting the boiler surface as the first step, it is the last to be considered in the preliminary design.

PRESSURE VARIES THROUGHOUT UNIT

Rating at which the boiler surface is operated is unimportant, as the rating is entirely dependent upon the maximum fuel feeding rate, draft facilities and the ability of the furnace to burn the fuel. There are some boilers supplemented by large air preheaters and economizers operating above 30 lb. per sq. ft. of heating surface with an availability factor of 95 per cent. The purchaser generally specifies the design pressure and the working pressure which may be stated in various ways, such as drum pressure, boiler outlet pressure, superheater outlet pressure or throttle pressure. On account of line drop, all these pressures are different although the same boiler is involved. It is, therefore important that the pressure should be distinctly specified to eliminate confusion and mistakes, especially in proposal work. For instance, if the steam pressure at the superheater outlet is given, it is necessary to determine the required working pressure of the boiler

drum in order to determine the drum thickness. To do this, the drop in pressure from the drum outlet to the inlet of the superheater and the drop in pressure through the superheater are added to the superheater outlet pressure, which result is increased by 4 per cent to allow for safety valve requirements. If in stating throttle pressure, for instance, the purchaser makes allowances of pressure drop which are too conservative, the specified design pressure may be just over the line of price increase. It is important, therefore, to take advantage of the highest pressure possible up to a major price change. It is also important not to call for an unnecessary pressure that just overlaps such a change.

Deaerators and Evaporators

Boiler manufacturers are often asked for an opinion as to the use of deaerators and evaporators. There are indications that deaerators are coming into general use as a protection to the boilers, even when no economizers are used, for all moderate and high pressure installations. When steel tube economizers are installed with the boilers, the use of deaerators is always desirable and becomes more so as the pressure increases. The use of evaporators for the protection of boilers and economizers depends upon the pressure, upon the rate of steaming and upon the character of the boiler water. High pressure plants are usually operated at such high evaporation rates that, as a general rule, evaporators should be considered necessary. There are many low pressure plants in which evaporators are required due to the character of the feedwater or load conditions.

In general, the maximum size and capacity of boilers have not increased over the maximum existing say a year ago. A 60,000 sq. ft. boiler is still a very large one and units which will deliver steam at the rate of 1,000,000 lb. per hour, or more, are still unusual. The rate of evaporation of 1,270,000 lb. of steam per hour from a C-E bent tube boiler fired by the Lopulco pulverized fuel system at the 14th Street Station of the New York Edison Co. is still the record. The maximum boiler operating pressure remains at 1840 lb. per sq. in. The number of boilers operating at 1200 to 1400 lb. per sq. in. is increasing, but there is a more pronounced increase in the 400 to 600 lb. per sq. in. class. In other words, we consider it safe to assume that the average steam operating pressure is increasing. However, there are relatively few installations in the range from 700 to 1200 lb. per sq. in. The upper limit of total steam temperature is in the neighborhood of 800 to 850 deg. fahr., although 750 deg. fahr. is more generally favored. In the stoker field, the maximum length and maximum combustion rates of multiple retort stokers have increased and there is a tendency toward a greater amount of water cooled surface in the furnaces.

Up to a few years ago, the principal development of pulverized fuel firing had been in public utility plants. Now in addition to the public utilities, there is an increasing trend of the industrials to pulverized coal, especially for the direct fired system. The maximum size of single units equipped with the direct fired system has increased to the neighborhood of 30,000 sq. ft. of heating surface, which speaks well for the reliability and flexibility of the present direct fired system. With the furnace completely water cooled and fired with pulverized fuel, the maximum heat release under operating conditions is approximately 43,000 B.t.u. per cu. ft. However, values between 18,000 and 35,000 are most common.

Overall efficiencies in the neighborhood of 90 per cent represent about the maximum limit with modern fuel burning and heat reclaiming equipment. In these upper limits of efficiency, a slight gain may be offset in the capital investment involved so that with present designs it is believed that the present maximum will not be increased.

Availability of boiler units may now be considered to be as high as turbine units. Several installations have been made consisting of a single boiler and turbine. For large furnaces, the all-metal, water cooled furnace is the usual construction for both pulverized fuel and multiple retort underfeed stoker firing.

Modern boiler room design is now well established in public utility plants and is gaining a foothold in industrial plants. Little sales effort is required to convince the managements of such plants of the value of stopping waste and saving money through the installation of up to date equipment.

Tired Boiler Plants

SUPPOSE that the boiler plant, after years of faithful service just gets weary because of age or of having too much load piled onto it. What can be done about it?

If all the equipment is just plumb worn out, apparently complete replacement is the logical answer. Frequently, however, part of the old outfit can be fitted into a plan for rejuvenation, with considerable saving in investment. When replacement of boiler units must be made, modern large units with overload capacity will naturally be chosen, requiring more head room than the old outfit. That may mean digging to set furnaces lower or raising the roof to secure greater head room. Floor area may be adequate but don't forget about those tubes which will have to be renewed sometime. Be sure there is room for it.

Stokers, of course, will promote economy for boilers of 200 hp. or over. If basement room is unavailable, a single retort underfeed will carry up to 600 hp. rating at 200 per cent of rating. Forced draft is necessary but can be put in small space by using a combined propeller fan and turbine unit discharging into the rear end of the ashpit. For larger units the multivane fan is compact and useful and alternative turbine or motor drive aids in maintaining proper heat balance.

If 10 t. of coal is fired a day, mechanical coal and ash handling will certainly pay and often is worth while for plants as low as 1000 hp. An overhead bunker of 2 or 3 cars capacity will serve 1000 to 2000 hp., if frequent coal shipments are reasonably certain. Cost of the coal handling plant,—track hopper, bucket elevator, screw distributing conveyor, gates, chutes and foundations, may run from $8 to $12 per boiler horsepower.

Piping with long radius bends, welded joints and good insulation will pay in the long run but using old pipe runs if they are available may materially reduce the cost of reconditioning the plant.

Wall insulation tends to greater comfort as it raises the temperature of the wall surface of a room.

POWER PLANT ENGINEERING September 1932

Pipe Bends Reduce Friction and Provide for Expansion

Common Types of Pipe Bends and Their Design, Inspection and Application. By Henry C. Moffett*

EVERY POWER plant design of today includes many bent pipes, all of which are generally referred to as bends. Bends are nearly always made to some radius and are made as smooth as possible for appearance. Some smaller sizes for low pressure work are bent without heat, but most bends are first heated in a gas furnace and then pulled to the desired shape on a bending table. A specially selected sand is packed into the pipe to prevent buckling or flattening while being pulled.

On low temperature lines, bends are valuable only to decrease the frictional loss in the pipe line by shortening the line; to cut down the number of flanged, screwed or welded joints that would otherwise be necessary and to improve the general looks of the piping layout.

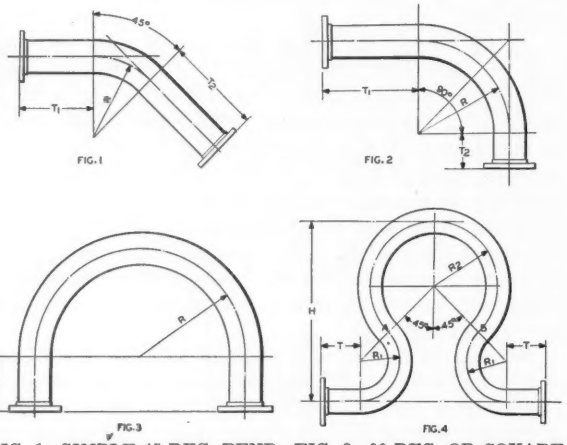

FIG. 1. SIMPLE 45-DEG. BEND. FIG. 2. 90-DEG. OR SQUARE BEND. FIG. 3. U BEND COMMONLY USED TO ABSORB EXPANSION AND CONTRACTION. FIG. 4. DOUBLE OFFSET EXPANSION U BEND

Lines carrying hot water, steam or other high temperature fluids are subject to expansion and contraction, which in some cases amounts to 7 in. per 100 ft. Unless it is feasible to install slip expansion joints, the shortening and lengthening of the lines must be compensated for by the proper use of pipe bends, so laid out as to take full advantage of the natural flexibility of the pipes and bends themselves. Such designs necessitate careful calculations for thrust and pipe stress, which in high pressure and temperature work marks the difference between safe and dangerous installations.

True bends have straight tangent lengths on each end. These may be short or long, as the case requires. Some manufacturers list standard bends, which for certain sizes of pipe have recommended standard radii and tangent lengths, and the minimum radii to which they are able to bend the pipe. These differ with the thickness of the pipe; the thicker the pipe, as a rule, the shorter the radii may be.

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Types of Bends

Figure 1 shows a 45 deg. bend. This is a simple bend in one plane. The tangent distances T_1 and T_2 are rarely the same in actual practice, but are made convenient lengths to suit the design. Fabricators and designers alike try to choose lengths so that the total length of the bent pipe will require as little waste as possible when made from random lengths. In many cases, when the position of the flanges or joints is immaterial, much can be saved by re-locating the connecting points so as to take advantage of the pipe lengths obtainable.

Figure 2 illustrates a 90-deg. or "square bend." This is probably the most common type of bend. Tangent lengths T_1 and T_2 are made equal on standard square bends; the minimum is ordinarily one inch greater than the nominal pipe diameter. Standards differ with manufacturers and some, by reason of special equipment, are able to make the tangents much shorter than others.

If flanges are to be attached, or laps turned on the pipe ends, these operations are finished before the pipes are bent, unless the flanges are to be fitted over welding stub ends, or are a part of butt welding flanges.

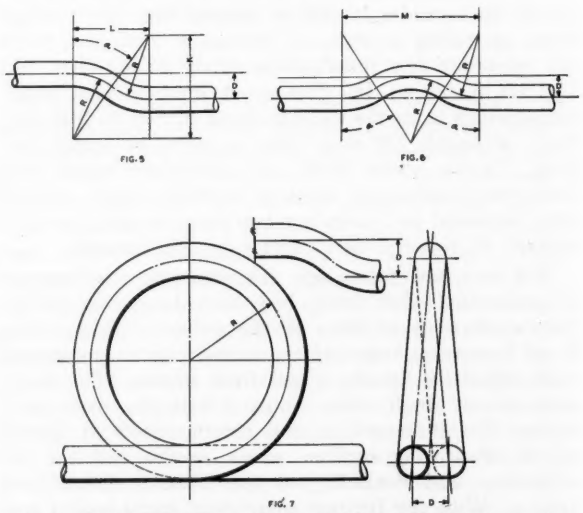


FIG. 5. OFFSET BEND. FIG. 6. CROSSOVER BEND. FIG. 7. CIRCLE BEND

"U" bends, (Fig. 3), more often than not, have the tangent lengths T the same. Sometimes Vanstoning is done on these after the pipes are bent.

"U" bends are almost always used to absorb expansion or contraction of the pipe line in which they are installed. These are usually erected in a vertical position, with square bends attached to each end. Properly designed and installed, maximum stresses may be shifted away from the flanged joints or other connecting points —an important advantage in any piping installation, as it tends to prevent leaky joints or excessive strain on welds.

Double offset expansion U bends, (Fig. 4), are usually made symmetrical. The radii R_1 and R_2 may be the same, but sometimes R_1 is made smaller than R_2, as shown in the illustration.

If the total length of the bend exceeds that of available pipe or tubing, it is necessary to weld two and sometimes three pieces together. The design must be changed slightly when this is done and small straight tangent lengths be left at points A and B, as these are the usual welding zones for this type of bend.

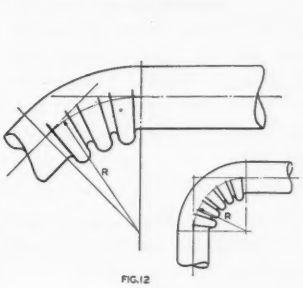
When flanges are necessary on expansion bends, steel flanges should always be used.

The offset bend, (Fig. 5), may be made with or without straight tangent lengths between the bent parts. Where possible, standard radii should be used. The length L may be calculated as follows:

$$K = 2R - D. \qquad L^2 = (2R)^2 - (2R - D)^2.$$
$$L^2 = 4RD - D^2.$$
$$L = \sqrt{(4RD - D^2)}.$$

Crossover bends, (Fig. 6), consist essentially of two offset bends, hence the distance $M = 2L$, provided the radii are all equal, and the angles "a" are the same. Crossover bends are useful in allowing one pipe line to pass over or under another, when the lines are mainly in one horizontal plane. Such bends are used also to circle around columns or other obstructions.

Circle bends, (Fig. 7), are strictly expansion elements, and are used only when space limitations do not allow other types. They are difficult and expensive bends to make, as one leg must be offset to bring the ends back in line. Such bends, especially on large diameter pipe, must be made from two or more lengths of pipe welded together.



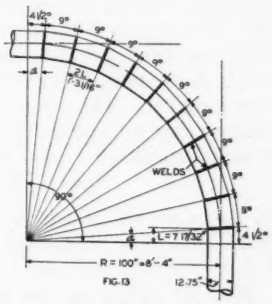


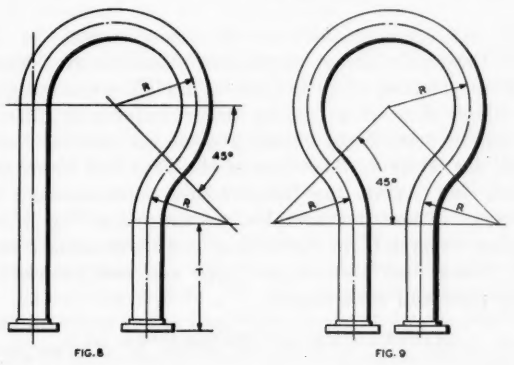
FIG. 12. CREASED BENDS. FIG. 13. WELDED BEND MADE UP OF SEGMENTS

Circle bends must be carefully guided along the horizontal ends in order to prevent buckling of the entire pipe line, as the thrust is not carried around the circle in one plane. Such bends have about five times the flexibility of a quarter bend and are almost always installed in a vertical position.

Single offset "U" bends (Fig. 8) and double offset "U" bends (Fig. 9) may have long or short tangent lengths, T, as conditions require, within the limits of available pipe lengths. Both of these types are used principally as expansion compensators. The radii of the upper portions may be equal or larger than the radii of the offset portions, as no standard practice exists on this point. Bends of this kind are sometimes looped around columns in a horizontal position, in order to save space.

Compound bends, (Fig. 10), may be either one continuous bend, part of which is bent to one radius and the other part to a different radius all in the same plane, or may be a continuous bend, part of which is one plane and part in another plane. Some compound bends are such that each point along the axis lies in a different plane. These are difficult to design and still more difficult to manufacture and are therefore rarely used.

Bends in two planes at right angles to each other, and tangents between, (Fig. 11), are common enough. Such bends are frequently made in planes at any angle to each other, especially on smaller lines around turbine foundations where clearances are small, and possibilities for getting lines in place at all, are few.



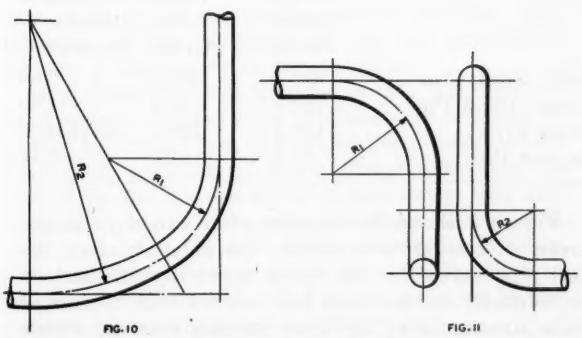


FIG. 8. SINGLE OFFSET U BEND. FIG. 9. DOUBLE OFFSET U BEND. FIG. 10. COMPOUND BEND. FIG. 11. COMPOUND BEND IN TWO PLANES

Creased Bends

Creased bends, (Fig. 12), have been used in Europe for years but it was not until a short time ago that they were introduced in this country. These bends are made from seamless tubing. The creases are forced to the outside of the full opening of the pipe, hence do not obstruct flow.

Creased bends can be manufactured with radii one and one-half the nominal diameters of the pipes. They are made in such a way that the walls of the pipes are not stretched and thinned on the outside of the bends

as is the case with ordinary bends and are more flexible. They can be made with long tangent lengths, which is advantageous as it allows greater factors of safety at the points of welding, or lessened stress in flanged joints.

Welded Bends

On atmospheric exhaust piping and frequently on exhaust steam piping, built-up bends are used. These are made from regular pipe, unless the diameters are great, by cutting out sections at predetermined angles, and then welding them together again after properly revolving them so as to form an arc approaching the shape of a circle. Figure 13 shows a welded bend with nine segments. The angle "a" is found by dividing the total number of degrees in the bend by twice the number of segments desired plus two, thus:

$$90 \div 20 = 4\frac{1}{2} \text{ deg.}$$

To calculate the inside length of each segment, shown as 2L, which is subtended by twice the angle "a" or 9 deg.

R is the radius of the bend, equals 100 in.

L equals (R — ½D) tan. "a," equals 7 17/32 in.

2L equals 1 ft. 3 1/16 in.

This welded bend is unusual, on account of the large number of segments. More often such bends have only three or four segments.

Welded bends of large diameter are more often built up from plates, pressed to shape and welded into place with both axial and circumferential seams.

Inspection

Bends should be free from buckles and blisters, and should be true to dimension. Improperly bent pipes sometimes become oval in section.

Inspection should be made to detect cracks on the outside where the greatest stretch takes place. Small flaws in a pipe wall will become readily noticeable after the bending operation.

Effect of Copper Sulphate on Pipe Materials

By C. C. McKee

IN COOLNG tower water systems, copper-sulphate ($CuSO_4$) is frequently used for the elimination of algae growth in water and the effect of this chemical upon the ducts through which it passes needs careful consideration. During an investigation, several samples of pipe metals which are in common use were subjected to such waters with the apparent result that copper or brass pipe would be the better construction material in such system.

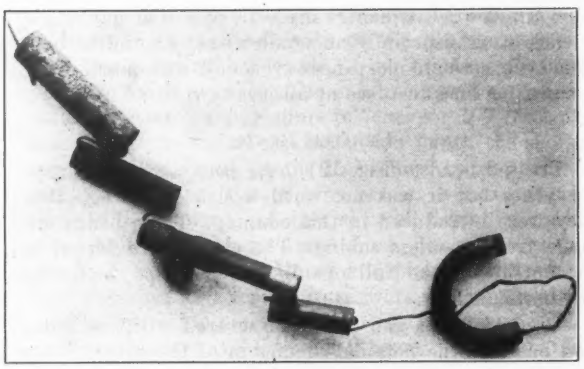


FIG. 1. PIPE SAMPLES AFTER TWO DAYS IN COOLING TOWER WATER

Where water is run over a cooling tower for the purpose of dissipating heat, the water in a great many cases is exposed to the direct rays of the sun, and algae growth flourishes. One common practice is to use a copper-sulphate solution of about one part per million in the circulating water.

This chemical ($CuSO_4$) is a common electrolyte and also when in solution, diluted to the extent mentioned, dissociates and becomes chemically active. When it is used, in proportion of 36 parts by weight of crystals to 100 parts by weight of water and the solution made neutral by the addition of an excess of chemically pure cupric oxide, the resulting solution is used in the "Preece Test" for removing zinc from galvanized articles. The facts are that copper sulphate will discourage the growth of algae and at the same time the electrolytic and chemical activity of this chemical on the ducts through which it passes should not be overlooked.

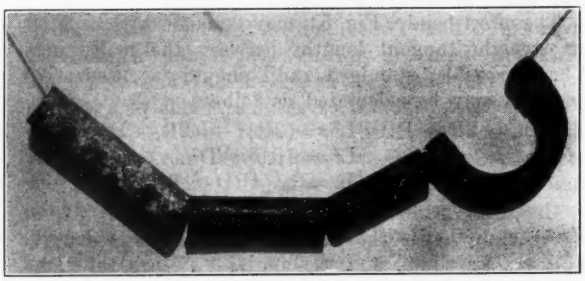


FIG. 2. APPEARANCE OF PIPE SAMPLES AT THE END OF THE 60-DAY PERIOD

Five samples of five different metals were hung in the direct flow of a cooling tower water and allowed to remain completely submerged in the cooling tower water for 60 days. The time of the year was February, March and April; the temperatures were average for the year. These five samples are shown in Fig. 1 and reading from left to right they are: Galvanized steel pipe, black steel pipe, copper pipe and cast bronze tee, brass pipe and copper pipe.

CHANGE IN WEIGHT DURING 60-DA. RUN

	Weight Before, Grams	Weight After, Grams	Percent of Increase + Decrease—
Galv. Steel Pipe	330.4	322.6	—0.66
Comm. Black Pipe	183.4	174.4	—4.90
Brass Pipe	139.1	139.1	No change
Copper Pipe	83.8	84.2	+0.47

Figure 1 shows the samples after two days in the stream of cooling tower water; the galvanizing on the steel pipe shows the zinc being vigorously attacked by the solutions and is rough and covered with blisters of white zinc-sulphate; the other samples show no visible change. The wire on which these samples were strung was eaten away, either by electrolysis or chemically, and

the copper tube and bronze tee were lost. The remaining samples are shown in Fig. 2 after being in the water for a period of 60 days.

Zinc on the galvanized steel pipe was completely washed away; the black steel pipe showed rust spots; the brass pipe was not changed in color; the copper pipe was slightly darker in color.

All samples were carefully cleaned, dried and weighed before starting the test, and at the end of the run (60 days) they were again cleaned, dried and weighed and the weights were recorded as per table.

This shows that brass pipe was the most inert and made no physical change, while the copper would hold second place in construction materials, due to the fact that it did not deteriorate but made a slight gain in weight. These facts substantiate the claims made by many operating engineers that their cooling water systems should be copper or brass pipe.

Making Boiler Tests

INSTRUMENTS SHOULD BE LOCATED SO AS TO BE OF PERMANENT OPERATING VALUE. BY J. G. BENTLEY*

SHORT BOILER tests under supervision give little indication as to annual cost per thousand pounds of steam. The annual fuel bill is dependent upon the results obtained by the regular plant personnel under routine operating conditions. Efficient operation necessitates operating data and to obtain this it is essential that suitable equipment should be installed. The equipment must be such that will serve as a check upon measurements so that accurate results will be assured.

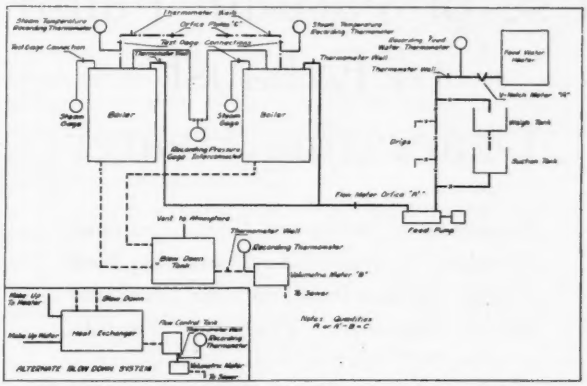
The accompanying drawing shows the various equipment necessary for accurate measurement of steam flow and the recording of that information necessary for calculations. The installation of the equipment will not only be essential for the comparison of two fuels, but will be of value to plant operation during the life of the plant. The maintaining of high operating efficiencies on any fuel which will be disclosed by the suggested equipment will return its cost in fuel savings in a few years.

Proposed method covers the accurate measurement of the water fed to the boilers, the measurement of the water blown down and the amount of steam produced. For routine daily operation, these measurements must be taken from meters. To disclose any inaccuracy of metering equipment, a means of check must be placed upon the various meters. In the proposed system the amount of water fed to the boiler as shown by the meter less the amount of water blown down will equal the amount of steam produced as shown by the steam flow meter if all meters accurately measure the flow. Any inaccuracy of flow measurement will be immediately shown by a discrepancy in the equation.

Arrangements should be made so that volumetric or actual water weights can be obtained over a period of 24 hours for the purpose of checking the accuracy of the system. The amount of water blown down can be obtained by the installation of a blow-down tank and measured by means of a volumetric meter. Calculation can be made of the amount of water flashed into steam by the reduction of the pressure from 300 lb. down to atmosphere. This amount added to that measured by the volumetric meter will give total blow down.

*Fuel Engineer, O'Gara Coal Co., Chicago, Ill. From appendix C of a paper presented at the Fifth Annual Midwest Bituminous Coal Conference, Purdue University.

There might be encountered difficulties in a satisfactory installation of a blow down because of local plant conditions. Operating under a steam pressure of 300 lb. for instance, the heat content per pound of water



METERING AND RECORDING INSTRUMENTS NEEDED TO GIVE COMPLETE DATA ON BOILER TESTS

under this pressure constitutes a heavy heat loss. The installation of a continuous blow down system with the usual heat exchanger would give the plant a decided thermal saving which would give a very good return on the investment. The installation of a continuous blow down system would materially increase the accuracy of the measurement of this factor. A volumetric meter and a recording thermometer would also be required with the heat exchanger.

This equipment shown on the drawing will not only be essential for the making of a test comparison between fuels but will also be valuable equipment in the continued satisfactory operation of your boiler room from an efficiency standpoint. Putting the boiler room on an accurate daily evaporative basis per unit of fuel used will readily show any drop in efficiency of operation or in quality of fuel used and give maximum evaporation.

As long as this evaporation is maintained as indicated by accurate measurement, high operating efficiency will result, which means low operating costs. The falling off of operating efficiency directly affects the evaporation per unit of fuel. When there is a decrease in evaporation per unit of fuel the plant operators can ascertain the cause of lowered efficiency by study of conditions.

STEAM CONDENSED in process coils submerged in water is given by T. H. Rea in Armstrong Trap Magazine as follows:

LB. STEAM CONDENSED PER SQ. FT. PER HR. IN SUBMERGED COILS OF VARIOUS METALS, IN WATER

Steam Temp. — Liquid Temp. Deg. F.	Wrt. Iron	Brass	Copper
50	10	16	18
100	32	50	58
150	66	100	114
200	110	164	186
300	220	330	380

These figures are for clean coil surfaces. Fouled surfaces will condense less; liquids containing solids will condense less; for viscous liquids, condensation will be ¼ to ⅛ less than the tabular values.

Use of Vacuum Pump to Exhaust Deaerating Heater

Protection of Boiler and Pipe Lines from Corrosion Is Insured by Deaerating Feed Water. Vacuum Pump on Vent Condenser Makes Automatic Operation Possible.

By JAMES J. HAYES

EXTENSIVE USE is being made in steam power plants of the deaerating heater which is the modern open heater of today. It may be employed in any plant where an ordinary open heater can be used. In the most efficient steam station plant, the feedwater is heated from condenser hot well temperature up to the boiler temperature by means of steam withdrawn from progressively higher pressure stages of the bleeder type of turbine. This is called regenerative feeding. Steam is withdrawn at several stages of this main turbine for use in extraction heaters, which may be either the closed or open type.

In order that the water may be deaerated or freed from dissolved gases, one of these stage heaters should be of the open or deaerating type. While some engineers claim that a reduction of free oxygen to from 1 to 0.5 c. c. per liter is sufficient to prevent corrosion, nevertheless oxygen should be reduced to 0.001 c. c. per liter to protect the piping, economizers, boilers and turbines completely.

Oxygen is insoluble in water at the boiling point—not necessarily the boiling point at atmospheric pressure, but at any pressure and corresponding temperature.

Practically complete elimination of oxygen and carbon dioxide can be obtained in the open deaerating heater. This process, however, depends in part upon the thorough venting of non-condensable gases from the steam space of the heater.

Deaerating heaters may be operated at pressures either above or below atmosphere or at variable pressures from one extreme to the other.

Use of Vent Condenser

If the steam space of an ordinary open heater, operated at a pressure above atmosphere, is vented directly to the atmosphere, a large amount of steam will escape, together with the non-condensable vapors and much heat will be wasted. To prevent this large heat loss a vent condenser is provided.

Figure 1 illustrates a 225,000-lb. per hour deaerating heater with vent condenser installed in the Weleetka Power Station of the Public Service Co. of Oklahoma, and the following text is a complete description of the unique system employed in this plant automatically to remove non-condensable gases from the heater and vent condenser.

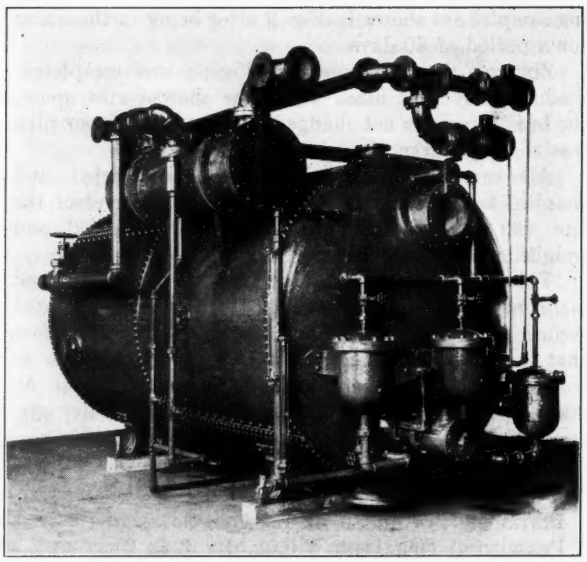


FIG. 1. DEAERATING HEATER WITH VENT CONDENSER USED IN WELEETKA POWER STATION

The vent condenser handles the air and steam from the heater vent. The steam is condensed by the cool water which is fed through the condenser tubes and then into the heater. The non-condensable gases pass out the atmospheric vent and the condensate is dripped back into the heater. The pressure on the heater and on the vent condenser may vary from 12 or 15 in. of vacuum to several pounds gage pressure, depending on the turbine load and other plant conditions.

If the heater pressure is above atmosphere the regulation of the venting may be accomplished by a hand valve, a thermostatic valve, or a diaphragm regulator. Under the opposite condition, when the heater is operated under a vacuum, an air pump or steam jet must be used to exhaust the vapors from the vent condenser and discharge them against atmospheric pressure.

When the steam ejector is used for this purpose, the heat of the steam required to operate the ejector may be recovered by a small closed heater or after-condenser.

Vacuum Pump on Vent Condenser

In the Weleetka Station the vacuum pump method is used to handle the vapors from the vent condenser due principally to the fact that complete automatic operation can be obtained with pressures on the heater varying from 15 in. of vacuum to several pounds.

It is highly desirable to accomplish automatic condenser venting, especially under extremely rapid load fluctuation on the main turbine unit. The motor driven centrifugal vacuum pump with suitable control equipment, provides a means of accomplishing this purpose. It automatically accommodates itself to all ranges of heater pressures or vacuums. It eliminates the use of steam ejectors, after condensers and exhaust steam line pressure reducing valves.

Figure 2 shows a diagrammatical arrangement of a centrifugal vacuum pump installation. This sketch includes the wiring diagram, as well as the piping layout.

It is difficult, if not entirely impossible, to give the reader an accurate method of figuring air pump displacements for various heater installations. In fact experiment seems to be the only one worth while. This is the same problem which confronted the designer of the first air pump for a vacuum heating system. Nobody knows how much air a vacuum system will require a vacuum pump to handle. Engineers simply guessed at the amount and hoped that they guessed large enough.

In the case of the vent condenser vacuum pump the amount of air capacity required depends upon the total heater load, the amount of make-up water used, the oxygen content of this water, the method of water treatment, the general design of the plant and its careful erection. On this particular job the air pump has a displacement of 16 cu. ft. per min. at 15 in. of vacuum. It requires a 1½-hp. motor at 1750 r.p.m.

From the vent condenser the vent pipe is connected to both the atmospheric vent through a diaphragm actuated valve and also the vacuum pump suction. The diaphragm atmospheric vent valve is of the double

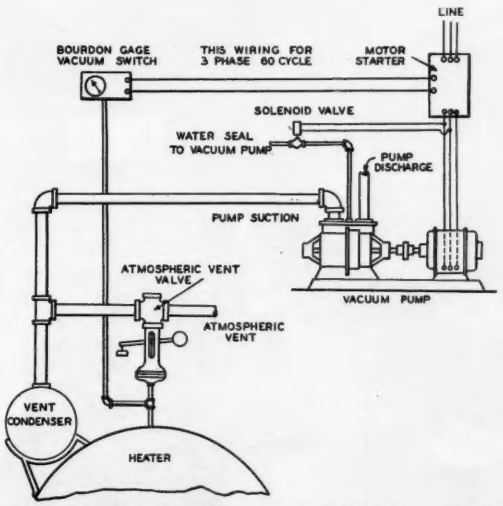


FIG. 2. DIAGRAM SHOWING ARRANGEMENT OF HEATER, VENT CONDENSER AND VACUUM PUMP

seated weighted type with its control pipe connected to the heater. This valve is adjusted by means of the weighted lever arm so that it remains open under all heater pressures above atmosphere. The control pipe of the regulator valve is also connected to a Bourdon gage type of vacuum switch which controls the action of the vacuum pump motor starter. At all times when the diaphragm vent valve is open, the vacuum regulator switch is open and the vacuum pump remains out of operation.

At the moment the turbine load causes the heater pressure to fall below atmospheric the diaphragm vent valve closes and the vacuum pump starter is thrown into contact. The pump then produces sufficient vacuum in the vent line to exhaust the vapors from the vent condenser. Should the heater pressure again rise to atmospheric or above, the vacuum pump goes out of service and the diaphragm vent valve again opens.

This system allows complete freedom in the design and operation of the plant equipment. The temperature to which the water is heated, controlled by the pressure, can be permitted to fluctuate with the turbine bleed point pressure, or according to the amount of exhaust steam available from auxiliaries, or with the amount of vapor available from an evaporator or according to the rate of boiler feeding. At the same time deaeration is complete at all times and at all temperatures.

In many steam power stations the amount of make-up water is small compared with the total amount of steam generated. In such cases evaporator equipment serves very well, a good grade of water is obtained nearly free from all chemical impurities. But this water must be deaerated. The deaerating heater may be used as an evaporator condenser.

In plants in which boiler feed make-up amounts to a large percentage of steam generated, evaporator equipment is seldom considered due to space requirements, high initial cost and maintenance. Most plants of this type employ other methods of purifying their water.

Changes in Boiler Practice

RAPID CHANGES have taken place in this industry during the past few years, but these changes have taken place so gradually that they are not apparent until one begins to compare the average figures of 10 yr. ago with those of today. The following data supplied by the Babcock & Wilcox Co. applies only to its equipment but is representative of changes in the industry.

In the year 1920 the average heating surface of all boilers sold was 4340 sq. ft., while in 1930 it was 7480, an increase of 73 per cent. Going hand in hand with the increase in size of boilers, there was an increase of evaporation per square foot of heating surface, improvements in methods of fuel burning, addition of water walls in furnaces and the addition of economizers or air preheaters.

In 1920 the average boiler pressure for all types of service was 162 lb. per sq. in.; today it is 332 lb. per sq. in., an increase of 104 per cent. This definitely shows the trend of boiler users toward higher pressures which, coupled with higher steam temperatures, has led to better efficiency of prime movers.

During this same period the total temperature increased from 400 to 500 deg. to a range of between 600 to 850.

In the year 1920 Babcock & Wilcox Co. put in its first large installation of steel economizers and in 1923 its first air preheater. The following table shows the growth of these heat absorbing units.

INCREASE IN THE USE OF AUXILIARY HEAT ABSORBING SURFACE IS REMARKABLE

Year	Number of economizer jobs sold with relation to the total number of boiler jobs %	Number of air heater jobs sold with relation to the total number of boiler jobs %
1920	.9	...
1921	1.7	...
1922	7.9	...
1923	5.9	1.
1924	4.4	4.8
1925	3.2	.4
1926	7.2	3.3
1927	11.1	13.0
1928	12.6	12.6
1929	13.3	23.8
1930	10.7	21.5

It is impossible to lay down any rules for the use of such auxiliary equipment as each job must be considered on its own merits. Given the fuel cost and the number of operating hours per year the added efficiency due to the use of economizers or air preheaters, or both, may be evaluated and fuel pile savings determined.

POWER PLANT ENGINEERING September 1932

Power Utilization

Remodeling Electric Systems In Industrial Plants

By W. A. COULTER*

Economy, Flexibility, Easy Control of Machines, Sufficient Capacity, Improved Power Factor Are Some of the Benefits from Remodeling

FIG. 1. IN THIS MACHINE SHOP NO LOCAL LIGHTING IS USED

IN THESE DAYS when practically every industry in the world is in a critical position it becomes necessary for every one of us to do some real and active thinking about the particular branch of industry in which we are engaged. There seems to be no doubt that the economic crisis we are going through will bring about major changes in all phases of business and industry. We read every day of evidences of new thinking along the lines of banking and finance; and it seems necessary that the generally accepted methods of merchandising and the distribution of manufactured goods will have to change also. New price levels will maintain and the manufacturer will have to bring all his ingenuity to the front to meet the new conditions. This will mean new consideration of plants and equipment and it is in this field that the plant engineer can do his part by studying his layout with an eye to the future.

It is true that we are still in the tearing down stage where companies are concentrating only on cutting expenses to the minimum in order to weather the low period but eventually and perhaps soon will begin the building up stage; this will be started by those companies who are determined to step out and get their share of the business that does exist today and who are not content to wait for the revival.

The plant engineer, therefore, should be ready with plans for new layouts and modernization to bring about the most economical operation of the plant. This will generally involve the remodeling of the electric distribution system, which should be done, not only from the economical point of view, but as well from the standpoint of flexibility in order to provide for rearrangements of machinery or the growth and extension of the plant. Sooner or later, changes are bound to be necessary in any progressive plant and it is good engineering to be ready for them.

Assuming that it is found advisable to remodel the electric distribution system, the first problem is the selection of the best system of circuits. To begin with, it

*Sikorsky Aviation Corp., Bridgeport, Conn.

generally works out better to separate the lighting and power systems as this provides better regulation and increases the service reliability. In case of an interruption in the power circuit, the plant would not be in darkness. If the lighting load is large in proportion, two main circuits will provide the proper balance in a two or three-phase system.

Many times the lighting system can be remodeled to produce greatly improved lighting at less cost and often resulting in an increase in production as well. Some systems, which have been in a number of years and which have proved inadequate have been built up by auxiliary local lighting with a resultant total load considerably greater than would be necessary with adequate general lighting and, even then, not entirely satisfactory. It has been demonstrated that, with an intensity of 18 foot-candles produced from general lighting, no local lighting whatever is necessary in, for example, a machine shop where close work is always required, as in Fig. 1.

Power Systems

For the power system, the most satisfactory scheme is to run separate feeders to each department or center of distribution. The first cost is high but justified by the fact that, if one circuit fails, there is no chance of interruption of any of the others. Another system that can be used to great advantage is the "loop" system. It is generally less expensive to install and has the advantage that it can be tapped at any point and local load centers created by bringing the leads to the panel serving a particular department.

Figure 2 is a schematic diagram of the loop system installed in a new, large aviation plant. Due to the changing requirements of the aviation industry, it was felt that from time to time it would probably be necessary to change the production layout and, with a rearrangement of machinery, there would be a consequent shifting of load centers. The loop feeder for the factory power service is a three-phase circuit of 1,000,000 c.m. section carried in a 4-in. galvanized pipe. This size of wire results in a negligible voltage drop at points where the power load taps are taken off and enables motors to be shifted at will to meet manufacturing conditions.

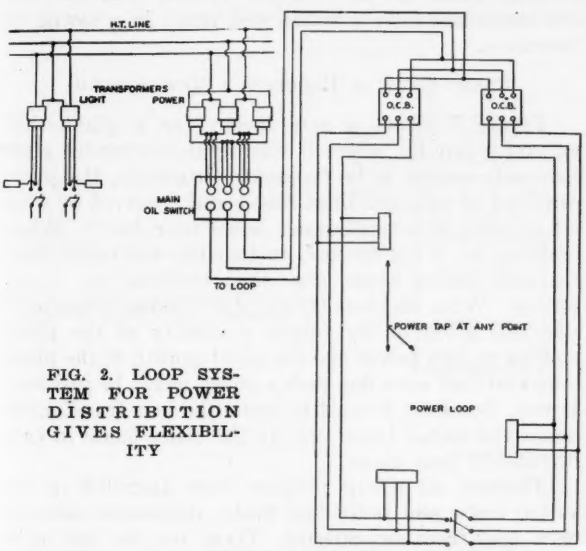


FIG. 2. LOOP SYSTEM FOR POWER DISTRIBUTION GIVES FLEXIBILITY

FIG. 3. MACHINE WIRED TO OVERHEAD DUCT WITH PUSH BUTTON CONTROL ON THE MACHINE AND STARTING BOX (NOT SHOWN) OUT OF THE WAY ON SIDE WALL OF BUILDING

At sixteen points on the loop 400-amp. taps are taken off and the motor feeds for individual machine tools, where grouped, are made through pipe conduit with connecting overhead branch ducts, having knockouts every few inches to facilitate machine location at any desired point. Small portable tools operated by 110-v. motors are supplied with energy through autotransformers whose primaries are tapped into the 220-v. loop as convenience requires. With this system, as many lines as are required can be laid in the overhead duct and taken to the machines. Additional lines are inserted by lifting a spring cover on the length of the duct involved.

All machinery in this factory is individually motor driven, following out the policy of complete flexibility which was adopted. Remote control is used for the motors wherever logical. On machine tools, the start and stop buttons are placed within as easy access as possible and magnetic starters are placed behind the machines or otherwise out of the way. Some valuable floor space was saved by mounting the starters for some of the larger machines on the wall, as in Fig. 3.

On each machine the motor has its own protection instead of attempting to protect motors in groups of several on one feeder. This enables trouble on one motor drive to be remedied without interrupting service on others and contributes materially to the maintenance of full production in the factory.

There is a good chance of a loop system being overloaded, so it is advisable to install automatic, overload disconnecting switches, either of the oil type or carbon circuit breaker type at both ends at the main switchboard. It is also well to insert a disconnecting switch midway on the loop, which in case of a short circuit, can be opened up and one-half the loop used while repairing the other section.

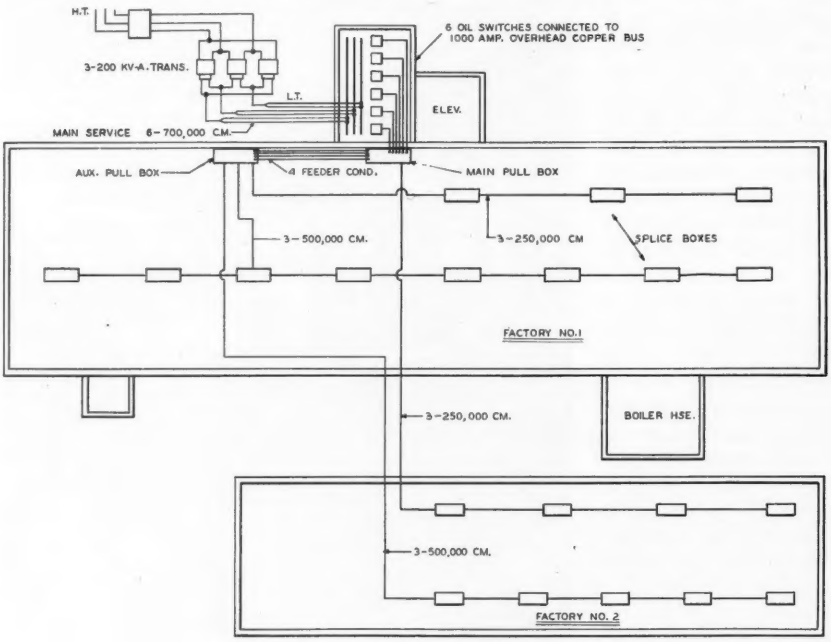


FIG. 4. THIS SYSTEM WAS USED TO REMEDY OVERLOAD AND PROVIDE FOR FUTURE EXPANSION

Remodeling an Overloaded System

In factories where the power requirements increase from year to year, or changes are made from time to time, it is common to find that the resultant electrical system is inadequate or poorly suited to the conditions. Figure 4 represents a new system that was installed in a factory where overloading of circuits resulted in frequent shut-downs due to fuses blowing at the main disconnect switches. The connected horsepower is 1200 and the whole factory was served by two 400-amp. disconnect switches. Entering the building to these switches were six 500,000 c.m. leads.

It was decided to build a new switch house and bring in six 700,000 c.m. leads from the transformers. These were paralleled on 1000-amp. overhead copper buses immediately over six automatic oil switches varying in sizes from 200 to 600-amp. From this point six circuits were brought out and run to various sections of the factory with pull boxes installed in each line of conduit so that panel circuits could be brought out from the main feeders at practically any point. The main bus bars are sufficiently large so that, if more manufacturing units are added, capacity will be sufficient for additional feeders and oil switches.

Automatic oil switches were adopted in order to eliminate fuses in the main feeders. Frequently, it happens that fuses will blow on an overload that is only momentary, perhaps due to the starting of several heavy pieces of machinery at the same time. In these cases the oil switches, if equipped with time-delay overload elements will not open the circuit. If fuses are used, they will blow out and much valuable time will be lost in replacing them. Sometimes only one fuse will blow, causing the motors on that feeder to run on single phase, which might result in some burn-outs. In the case of a short circuit, it would be evidenced immediately by the fact that the oil switch would throw out again as soon as it was reset. On the other hand, where fuses are used, a short circuit might only be told by the fuses blowing again. Oil switches are, of course, much safer and sometimes their selection will result in a saving in insurance.

Plant Growth Required a New System

Figure 5 shows a new layout for a plant that expanded rapidly, where it was decided to rewire after blow-outs started to be frequent. Originally, the plant consisted of only buildings Nos. 1 and 2, served by four oil switches in a transformer house near No. 1. When building No. 3 was erected, another tap was taken from the transformer house, also when building No. 4 was put up. When the new lay-out was planned, consideration was given to the future possibility of the plant making its own power and the rapid growth of the plant indicated that some day such a policy might be justified. It was, therefore, decided to locate the new transformer house and switch house next to the boiler house in case this should come about.

Thirteen oil circuit breakers were installed in the switch house and individual feeder disconnect switches on a dead-front switchboard. There are also one main metering panel and two panels for the controlling of two 150-kva. capacitor banks for the plant power factor correction. From this point, immediately in the rear of the switchboard, new feeders of lead cables were run to the other buildings in steel conduits underground, terminating in dead-front enclosed power distribution panel boards.

From these distribution points, new feeders were installed overhead with splice boxes every 30 ft. in each feeder, allowing taps to be taken off and brought down

to department panel boards. Nearly all of the machinery in this plant is individually motor driven, the starting apparatus in most cases being mounted directly on the machines. All starters are equipped with the proper overload and undervoltage release devices. On several of the large machines, the start and stop push buttons were installed in tandem so that starting and stopping could be done at different locations around the machinery. Further protection was provided through emergency locking stop buttons so that the machinery could not be started again until any trouble had been located and corrected.

Main feeders are so located that new machinery may be installed, and wired and connected to any one of the new feeders in a short time.

In this layout, fuse panels were adopted because the installation of so many automatic circuit breakers would have made the first cost out of all proportion. All main feeders are, of course, backed up with oil circuit breakers with time-delay overload devices.

Originally, the power-factor in this plant averaged 55 per cent. With the installation of the 300-kva. static condensers, the power-factor was raised to an average of 80 per cent, which not only eliminated a lot of wattless current in the distribution feeders but lowered the power company's charges appreciably.

Higher Power Factor Gives Lower Power Costs

Although more attention than formerly is being given to power-factor in industrial plants, a low power-factor condition is often overlooked or neglected. Many power companies have preferential rates or penalty for low and bonus for high power-factor which automatically induces attention from their customers but, where such clauses do not exist in rate schedules, investigation would turn up many conditions of low power-factor existing without the knowledge of the plant managers. It is a situation which generally develops because of the growing tendency towards individual motor drive and the practice of adding motor installations without consideration of the effect on power-factor. Many times the heating of cables in an electric distribution system has led to the conclusion that the system was over-taxed and the capacity apparently too small but afterwards this was found to be really due to the large magnetizing or wattless currents from large inductive loads, which, in most cases, is caused by too many over-powered machines. Low power-factor can be corrected by the substitution of synchronous motors in certain places or the installation of corrective apparatus designed for this purpose. In plants where the cost of such apparatus would be prohibitive, it would be worth while to attempt to improve conditions by the rearrangement of motors or the institution of some group drives. Sometimes the power-factor can be raised to an entirely satisfactory percentage by this method and even if no direct saving in rates is gained, the improved efficiency will in itself bring down the power bills.

Plans Are Worth Making Even If Remodeling Is Delayed

In general, it is worth while giving consideration to all phases of the use of power with the ultimate object of reducing costs. Under present economic conditions, it is difficult to secure any appreciable investment for new equipment but, for those who are in a position to do so, any modernization work can be accomplished now at least cost. At any rate, it is important to analyze conditions thoroughly and make plans for the rehabilitation of your system, to be carried out at the first opportunity. It may be, for example, that the original reasons for buying or making power do not now apply, either because of an increase in consumption or a change in the character of the particular industry. In the last decade, desire to increase production has been so great that economy has been too often sacrificed to this end. The policy, for instance, of individual motor drive has been greatly overdone. It has many advantages, and, in many plants is entirely necessary but in many cases return to at least partial group drive would result in substantial savings in the power bills. We have the example of a manufacturer who traded in many small motors for about half their value yet was able to get in exchange for them enough new and larger motors for

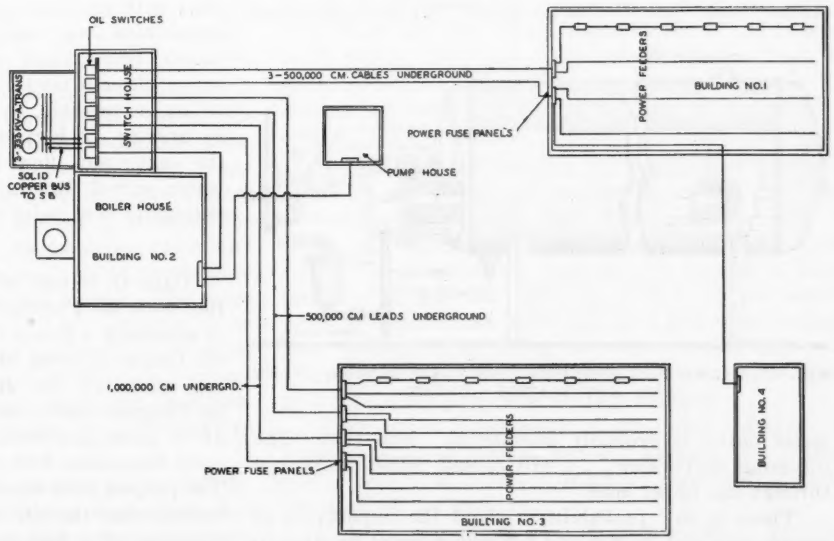


FIG. 5. NEW SYSTEM TO PROVIDE FOR PLANT GROWTH

group drives to result in savings that paid for the change-over in sixteen months.

Consultation with the power company is always advisable and often results in recommendations for beneficial changes. Most of the utility companies are broad-minded enough to recognize that savings on the part of their customers will, in the end, accrue to their own benefit and every advantage should be taken of their knowledge and experience.

Water Heater Connections

On this subject, Patterson-Kelley Co. makes the following comment: "Regarding the standard location of our water inlet and outlet connections for storage-type heaters, more satisfactory results are obtained than when they were located some years ago in accordance with the method outlined in the May 15 issue by Mr. O'Brien."

Another heater manufacturer says: "As to location of the cold water and hot water connections on a storage-type heater, we have found that it makes no difference in the heating capacity of the heater, which way connections are made. Tests show that heat travels from the heating element through the water by conduction when the water in a tank is under pressure.

"As to the statement that the thermometer at the top of a tank will read 200 deg. when temperature at the regulator bulb is 100 deg., we disagree. We contend that, in a storage heater under pressure, water does not stratify and there is no circulation of the water. In such a heater not under pressure, there will be rapid circulation of water and the heated water will stratify."

Mr. O'Brien's comment is as follows:

In connection with the letter by C. O. Sandstrom I am willing to admit that the question of heat exchange and expansion strains is arbitrary and could better have been omitted from my article. This will give Mr. Sandstrom "Score One." But he states "The location of hot

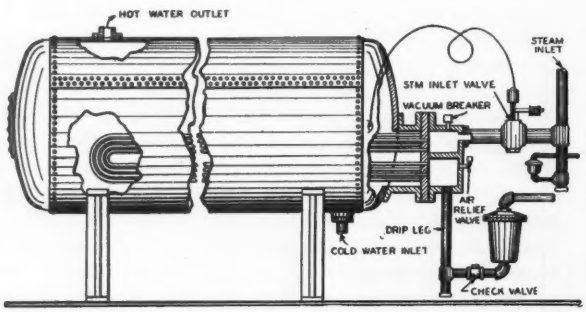


FIG. 1. USUAL ARRANGEMENT OF COLD WATER INLET AND HOT WATER OUTLET

water outlet is probably immaterial," and that "The incoming cold water . . . will spread rather uniformly through the upper zone."

There is no "probability" about the importance of correct cold water inlet and hot water outlet location in relation to the position of the thermostatic bulb. The fact remains that anyone who has ever been responsible for servicing temperature regulators has learned that the thermostatic bulb must be in the representative location, that is above the heating element and in the path of the hot water outlet. Mr. Sandstrom overlooks the fact that this system is under pressure and, when no water is being drawn, the only movement is due to thermal difference.

With the storage type of heater it has been observed that, even when the water in the upper section is heated up to temperature, a sudden, heavy draw on the hot water outlet, continuing for any extended period will draw cold water, even though hot water remains in the upper, opposite end of the tank, due, no doubt, to the rapid pressure drop and failure to equalize for pressure difference between cold water inlet and hot water outlet.

I am glad to agree on the importance of draining of condensate and elimination of the air from the heater.

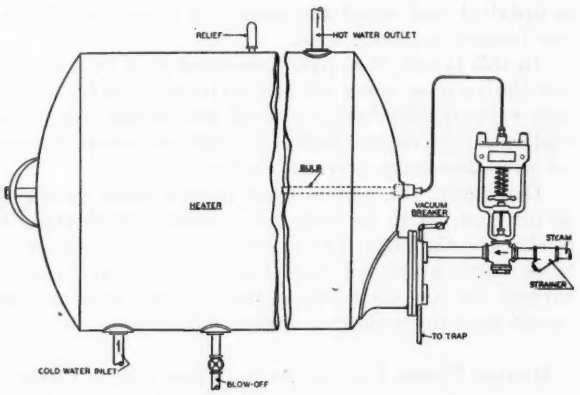


FIG. 2. WATER CONNECTIONS AS SUGGESTED BY MR. O'BRIEN

By reference to Fig. 1, criticised in my article, you will note that a check velve is provided between the water outlet and the trap inlet. It is usually figured that about 12 in. of water head is needed to open a check valve. This is, no doubt, installed to prevent the siphoning of the seal from the trap but it handicaps good drainage. The trap outlet is shown as almost on the level with the lower coils of the heater element. If an installation was made in strict accordance with the sketch, there would no doubt be condensation in the heater element most of the time. Traps should be placed as low as possible, so as to provide maximum drainage by gravity. A horizontal inlet and outlet type trap of the continuous flow type is, in the writer's opinion, better suited for this service. A built-in or separate automatic vent valve should be incorporated.

Carl G. Stifel of St. Louis, Mo., has filed application with the Federal Power Commission for permission to construct a power dam on the Mississippi River near the Chain of Rocks bridge, the Commission in turn giving notice of the application to the St. Louis and St. Charles county officials of Missouri. They, the City of St. Louis and firms and private individuals will have until September 15th to file objections to the application. The project is to develop 175,000 hp. to serve industries located near the site of the dam, also includes the construction of a lock system near the Missouri shore of the river and an earth embankment to connect with the existing system of levees on the Illinois shore, where the power house is to be located. It is estimated that the proposed dam will raise the low water stage of the river above the dam to 25 ft., backing water as far upstream as Grafton, Ill., near the mouth of the Illinois River, a distance of about 15 to 20 miles.

Material Handling for Economy*

By George Paull Torrence**

PROPER place of material handling machinery in economy of industrial operations is being given much thought by users of such equipment. Doubt has come into the minds of many as to the social wisdom, in these days of widespread unemployment, of all devices that make for increase in production in proportion to the number of workers employed. Some feel that technological unemployment has developed to too great an extent due to devices for saving labor. Conscientious citizens as well as manufacturers want to analyze these trends of thought to be sure that they are on sound ground, ethically as well as practically.

Material handling devices are one group of labor savers, machine tools, agricultural machinery and almost every modern tool and electrical device are others. Either all are wrong or all are ethically wise. The term "labor saving" is more frequently applied to material handling and other devices that replace common labor than to those that replace skilled workmen, perhaps because it might seem easier for common labor to find new opportunity. The result is, however, the same in all cases.

Many times statements have been made that the people of the United States have more material things to make their lives worth while and more educational advantages than any other nation has achieved; this because shorter working hours make possible the enjoyment of these advantages. We have thought ourselves prosperous. For the moment, our situation is out of gear but this does not change fundamental reasons which make possible widespread distribution of material, educational and social advantages.

One hundred years ago, more than half the people of the United States were farmers; more than half the population were needed to feed the nation. Today 20 per cent of the people are on the farm, producing, with the aid of machinery, the food needed for themselves and the other 80 per cent, with surplus sufficient to demoralize the prices of farm products. Take away mechanical equipment from the farm and again more than half the people would be needed to produce the food required for the nation. Automobiles, radio and like comforts could not then be available to people generally. Simple arithmetic gives the answer. The more things we can make, the more will be available to be distributed and used among us. Distribution of material things and leisure for enjoying them and educational and cultural advantages are dependent upon production by machinery which enables an individual to make more units in less time.

Today our problem is not to abandon mechanical devices but to get our financial structure working so that distribution of products from quantity production machinery will be re-established. Labor saving machinery, including material handling equipment, is necessary to the well being of our country. How can material handling devices be used to help re-establishment of business on a sound and enduring basis?

Development of the present situation may continue in a number of ways. Workers and families may drift back to the land to produce for their needs and to exist without much money or dependence upon others. If this becomes widespread, it will set back civilization and development a hundred years. Another phase of the same sort is continued expenditure by government bodies of large sums, out of all proportion to the income of people and business firms, with consquent demoralization of the credit structure of our country. Continued long enough, the dollar will become worthless and we shall all start over again having nothing but the material things we possess and no medium or method for exchange except barter. Neither government nor individuals can continue to spend beyond income without disaster.

Another way is for business and industry to take the position in thought and practice that the way out of the present hazardous situation is for business and industry to reorganize on the basis of present volume so that each enterprise becomes profitable instead of a losing venture. If, today, it were possible for each business and industry to pay fair wages, make a profit and distribute dividends to owners, our present depression would shortly end. Unless steps are taken to that end, depths reached before the upturn may be great indeed.

Acting on the theory that the present situation is temporary and is bound to turn without any constructive action on their part, many enterprises have thought that their salvation lay in getting more than a proportionate volume of business, usually by entire disregard of actual costs of production. The result has been disintegration of prices of raw materials and commodities with resulting loss to producers. It is quite generally true that business is being done at a loss, which, obviously, cannot continue indefinitely. It is dangerous to *wait* for the turn.

Profit or loss is the difference between the cost of a product and the return received for it. If cost exceeds return, the result is loss, which in some cases has recently been of astounding proportions. To make the balance favorable, selling prices may be increased or costs reduced.

If, as recent discussion in newspapers and magazines of the failure of passage of a sales tax seems to indicate, the people feel that some per cent increase in sales price was wise to insure integrity of the government, it should also be wise to insure integrity of business. Advance of 5 to 10 per cent in price of commodities now sold at a loss would change most business from losing to profit showing and re-establish stability. That achieved, business would grow, as it has in the past from every low point.

Since profit is essential to continued stability, the feeling should be general that any business that deliberately operates at a loss is definitely contributing to the downfall of the country.

It is in reduction of cost that material handling equipment can do its part. Properly applied, it may be a large factor in the reduction of cost of manufacture. It is proper that manufacturers of equipment emphasize this. Equipment should be classed as *labor aid* not labor saving and manufacturers should preach and practice the necessity for profit. The way to prosperity is forward from the present low basis by making profit now.

*From an address before Cincinnati Section, A.S.M.E.
**President, Link Belt Co.

POWER PLANT ENGINEERING September 1932

Parallel Operation of A. C. Generators

Part VIII. Methods and equipment used in synchronizing. Beat frequencies and voltages. Synchroscopes. Current and power conditions for different angles at which circuit breaker may be closed

By
E. H. STIVENDER

SYNCHRONIZING OF GENERATORS may be accomplished either manually or automatically. There are a number of different instruments manufactured for the purpose; for use in manually operated stations they indicate by means of pointers the relative phase angles between the two voltages to be synchronized. Automatic synchronizers are devices which complete the closing circuits of the circuit breakers either at, or prior to synchronism.

In manually operated stations, after the machines have been brought up to approximately synchronous speed, the governor is manipulated either directly by hand or by remote control, by means of a synchronizing motor, until the synchroscope indicates proper phase relations for closing the oil switch. In automatic stations the machine automatically comes up to speed when started by some automatic device, or by remote control from a removed point; speed matching mechanism then matches the frequency of the generator with that of the line and the circuit breaker is closed through con-

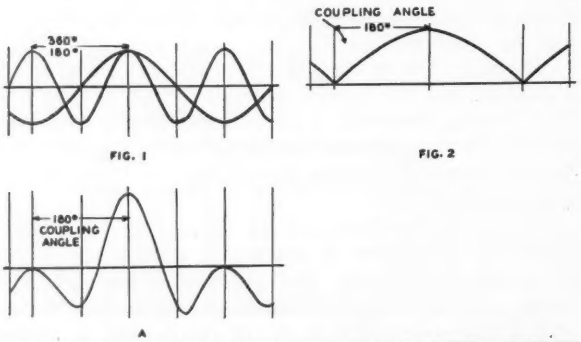


FIG. 1

FIG. 2

FIG. 1. ILLUSTRATING TWO SINE WAVES DIFFERING IN FREQUENCY
(A) The resultant wave
FIG. 2. VOLTAGE MAGNITUDE CURVE OBTAINED FROM FIG. 1

tacts of an automatic synchronizer when favorable phase relations are reached.

In substations where automatic reclosing switches are employed, devices are sometimes used which check the phase relations on each side of the circuit breaker before it can be closed by the reclosing relay. These devices are distinguished from automatic synchronizers in that they are intended to prevent two lines being tied together if they are differing too greatly in frequency or phase angle. They are not sufficiently precise in operation to be used as synchronizers, and are classed as relays to be used in connection with automatic reclosing relays.

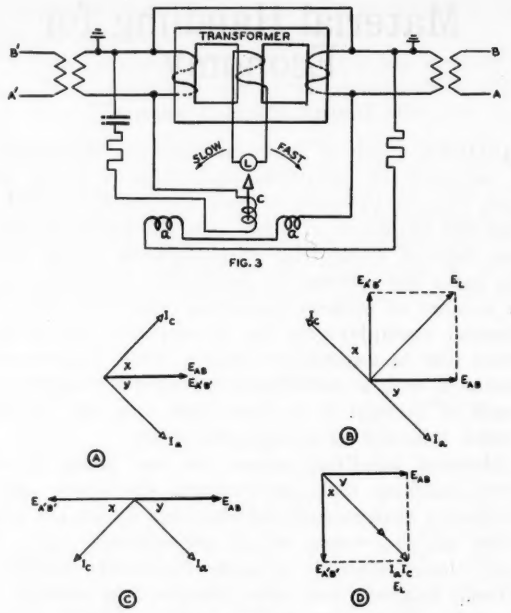


FIG. 3

FIG. 3. THE CIRCUIT OF THE WESTON SYNCHROSCOPE
(A) Voltage and current relations at synchronism
(B) $E_{AB'}$ is 90 deg. ahead of synchronism
(C) $E_{AB'}$ is 180 deg. out of synchronism
(D) $E_{AB'}$ is 270 deg. ahead of synchronism

This article deals with some of the more generally used synchronizers and synchronism indicators.

When a generator has been brought to approximately synchronous speed, and the synchroscope and lamps have been connected into circuit, the lamps indicate periodically bright and dark; where the lamps are connected for "dark lamp synchronizing" the dark periods indicate instants when the generator frequency is in step with that of the line. The voltage across the lamps is the sum of two sine wave voltages, which is zero at synchronism. Fig. 1 illustrates two sine waves, representing two equal voltages differing in frequency; their resultant wave is shown in Fig. 1A. If voltage magnitudes are represented in the order of which they would appear on a voltmeter connected across the lamps, the curve of Fig. 2 will result. Curves similar to this were derived by vectors in preceding articles.

The brilliancy of a lamp will not follow the curve of Fig. 2 nor will the torque of a relay or coil, since heat and torque in such cases are proportional to the square of the impressed voltage, hence the lamp brilliancy (assuming the resistance remains constant) may be represented by a curve plotted from the squares of the different values in Fig. 2. Since Fig. 2 shows one half cycle of a sinusoidal curve ($y = 2 \cos \frac{1}{2} x$), the lamp brilliancy curve for constant resistance will be a sinusoidal curve of double the frequency of Fig. 2 and will approach zero at the same rate as it approaches maximum. The double frequency curve will of course have no negative values.

As has been mentioned before it is preferable to use carbon filament lamps for bright lamp synchronizing and tungsten filament lamps for dark lamp synchronizing.

In modern installations synchronizing by lamp indications is usually done only in cases of emergency—when the synchroscope is out of working order, or one is unavailable. Lamps are usually provided only as

accessories to the synchroscope. When it is desired, the indications of lamps may be used to show relative difference in frequency of the machine and line, when this difference is beyond the range of the synchroscope. Modern synchroscopes usually begin to indicate when the machine is within 10 per cent of synchronous speed; beyond that range the mechanism cannot be made sufficiently sensitive to permit the rugged construction required for general service.

Machines may be safely paralleled when the voltages are equal, the wave shapes are similar, and when they are in step. The effects of paralleling when conditions other than correct exist have been discussed to a greater extent in earlier articles.

The Weston Synchroscope

There are two general types of synchroscopes, the vibrating type and the rotating type. The vibrating type is known as the Weston type, rotating types are based on the Lincoln principle.

In Fig. 3 is a diagram of the connections of a vibrating synchroscope. This instrument indicates by means of an illuminated scale and pointer at what angle the incoming machine is approaching synchronism and at what relative speed it is, compared to the line frequency. It is distinguished from the rotating types in that the pointer never makes a complete revolution, but by the action of a specially connected lamp and actuating coils, gives the appearance of doing so.

Coils (a) are stationary and are connected to one bus through their respective resistor; the circuit of movable coil (c) contains a condenser and resistor. The lamp transformer contains two primary windings and a secondary winding, from which the lamp is energized; the windings of the transformer are so connected that the flux in the core is zero when the machine is 180 deg. out of synchronism. Since it is general practice to ground the same phase on all potential transformer secondaries and since the operation of the synchroscope depends for its operation on the lamp being bright at synchronism, it is necessary to use a transformer in the lamp circuit.

When a coil energized by alternating current is placed in the proximity of another coil of equal turns and energized by an alternating current of equal value and similar wave shape, but at 90 deg. to it, no magnetic attraction or repulsion exists between the two coils, because when the current, and therefore the flux, of one coil is at maximum, that of the other is at zero, and vice versa. By placing a condenser in the circuit of coil (c), Fig. 3, the current is made to lead the voltage of the circuit; owing to a certain amount of inductance in the circuit of coils (a) the current through coil (c) will not be exactly at 90 deg. to that of coil (a) unless resistors of the proper value are provided in the two circuits. In Fig. 3 (a), voltages E_{AB} and $E_{A'B'}$ are in phase when the generator is in synchronism with the line. If the current I_a through coils (a) lags by the angle Y, then the resistor in the circuit of coil (c) must be of such value as to make angle X plus angle Y equal 90 deg.

A spring holds coil (c), which carries the pointer, at a position where the axes of the coil fluxes will be 90 mechanical degrees from each other, hence when no current flows through the coils the pointer remains at the center of the scale. This is the position of synchronism, and the lamp is bright. When the lamp is dark any motion of the pointer is concealed, since it is behind a translucent scale. This scale covers nearly the upper half of the instrument.

In the vector diagrams, a rotation of $E_{A'B'}$ in a counter-clockwise direction indicates the incoming machine is faster than the line frequency. Since the fluxes in the transformer always bear a definite relation to the voltages, we may consider the voltage vectors as representative of the fluxes proportional to them, hence in Fig. 3 (A), E_{AB} and $E_{A'B'}$ are in the same direction and the fluxes are added; the voltage across the lamp will be twice that when only one primary coil is energized. The attraction between coils (a) and (c) is zero and the pointer is held in the center of the scale.

In Fig. 3 (b), $E_{A'B'}$ has moved 90 deg. counter-clockwise, the voltage E_L across the lamp is 141.4 per cent. The angle between the currents of coils (a) and (c) is

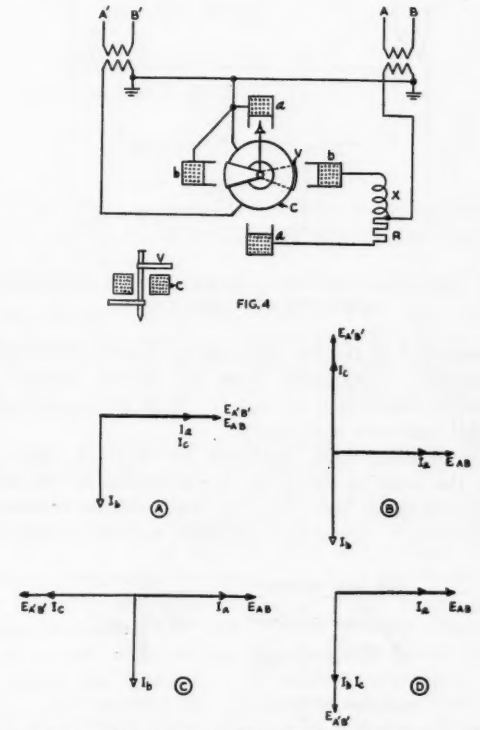


FIG. 4. THE CIRCUIT OF AN INDUCTION TYPE SYNCHROSCOPE

(A) Voltage and current relations at synchronism
(B) $E_{A'B'}$ is 90 deg. ahead of synchronism
(C) $E_{A'B'}$ is 180 deg. out of synchronism
(D) $E_{A'B'}$ is 270 deg. out of synchronism

180 deg., hence there is maximum attraction between them. Consider for convenience that coil (c) moves 90 deg. clockwise to throw the fluxes in line. At the position of Fig. 3 (C), $E_{A'B'}$ has moved 90 deg. farther, the lamp is dark and I_a and I_c are at 90 deg., causing the spring to pull the pointer to the center of the scale. In Fig. 3 (D), E_L has increased to 141.4 per cent and I_a and I_c are in phase, causing the pointer to swing in a counter-clockwise direction to the right hand side of the scale. As the lamp becomes brighter, coil (c) swings back to the center in a counter-clockwise direction, then as the brilliancy decreases, (c) moves back to the right hand side of the scale.

By observing the above indications it can be seen that while the lamp is bright the pointer swings to the right, while it is dark the pointer swings to the left. Taking the vector diagrams in the order D - C - B - A, denoting a clockwise rotation of $E_{A'B'}$, and hence indicating the machine is below synchronous speed, the pointer swings to the left when the lamp is bright and to the right when it is dark; an apparent clockwise rotation of the pointer is given when the machine is faster than line frequency, and an apparent counter-clockwise rotation is given when the machine is below line frequency.

The Westinghouse Synchroscope

In Fig. 4 is an elementary diagram of a rotating synchroscope of the induction type. Coils (a) and (b)

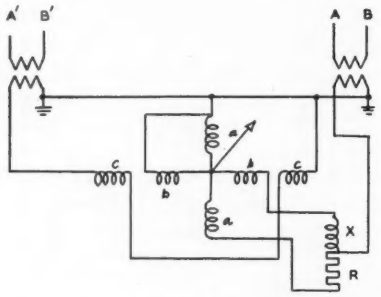


FIG. 5. THE CIRCUIT OF A ROTATING ELECTRO-DYNAMOMETER SYNCHROSCOPE

are connected to the bus through a resistor and reactor respectively, a movable vane V, which carries the pointer, is magnetized by coil (c) from generator potential. All coils are stationary.

The rotating field produced by coils (a) and (b) causes the vane to rotate in one direction or the other, corresponding to the speed of the machine relative to line frequency. By observing Figs. 4A, B, C and D in

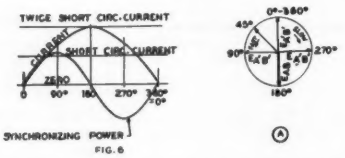


FIG. 6. CURRENT AND SYNCHRONIZING POWER RELATIONS FOR DIFFERENT PHASE CONDITIONS PRESENT AT CLOSURE OF THE CIRCUIT BREAKER. THE INSTANTANEOUS CURRENT MAY REACH MUCH HIGHER VALUES THAN THAT SHOWN

(A) When the breaker is closed on the vertical half marked "fast," generator action takes place. On the half marked "slow," motor action takes place. This condition has no bearing on the relative frequencies of generator and line.

succession, the phase relations of the flux of coil (c) relative to (a) and (b) is given at 90 deg. intervals while the machine is running above synchronous speed. At 4(A), I_c is in phase with I_a and at 90 deg. to I_b; at 4(B), I_c is 180 deg. from I_b and 90 deg. from I_a, hence the pointer rotates 90 deg. Similarly continued rotation may be traced through 360 deg. of rotation of $E_{A'B'}$. Taking the diagrams in the order (D)—(C)—(B)—(A), indicating a clockwise rotation of $E_{A'B'}$, the rotation of the pointer will be in the opposite direction to that indicated above. The coils are so aranged and connected that the pointer turns counter-clockwise when the machine is "fast" and clockwise when it is "slow".

The General Electric Type AR-2 Synchroscope

The operation of an electro-dynamometer rotating synchroscope is similar to that of the induction instrument described. Fig. 5 is an illustration of the circuit of a rotating electro-dynamometer synchroscope. Movable coils (a) and (b) are energized through slip rings, the circuit of (a) contains a resistance and that of (b) contains an inductive reactance; the rotating field of these coils acting upon that of stationary coils C, causes a rotation of the pointer in accordance with the relative frequencies of the machine and line.

Owing to the practical impossibility of producing an absolute 90 deg. displacement of current by means of a resistance and reactance so connected, the movable coils are mounted nearly 90 deg. apart, in order to indicate accurately the phase angle when the machine is approaching synchronism. These instruments move clockwise to indicate "fast" and counter-clockwise to indicate "slow".

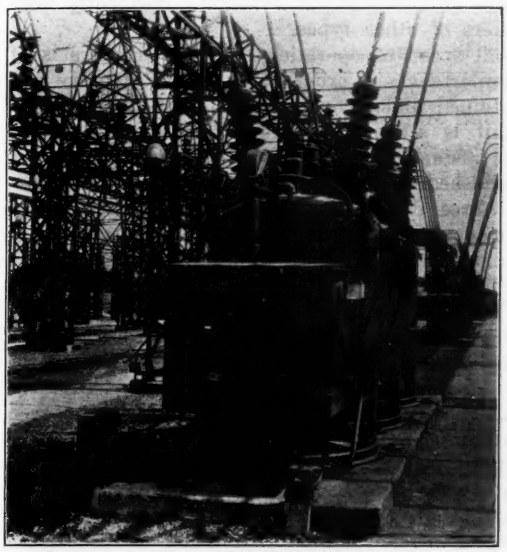
The circuit breaker should be closed when the pointer is rotating at speeds from about one revolution in 5 seconds to stationary at the point of synchronism. Where manual synchronizing is employed, as is the case in the larger stations, the speed of closure of the circuit breaker must be estimated in order that the control switch may be operated at the correct instant before the point of synchronism is reached. This general rule of closure before the pointer reaches 12 o'clock is a necessary precaution in any case; the control switch should never be closed after the pointer has passed the point of indicated synchronism.

Fig. 6 is a graphic illustration indicating the r.m.s. current flowing and the synchronizing power which exists for different angles at which the circuit breaker may be closed. The perfect point of closure is at zero degrees; if the breaker is closed at any point between 0 and 180 deg., the generator will deliver positive power (above the zero axis), meaning generator action, hence tending to slow the machine and increase the speed of other apparatus on the system. At points between 180 and 360 deg., motor action is present, since the power curve is below the zero axis, representing negative power, and the machine tends to increase in speed. If the breaker is closed between the 90 and 180 deg. points, any increase in speed tends to decrease the braking action of the synchronizing power and the machine pulls farther out of step, causing the current to reach its highest value at the 180 deg. point, where the synchronizing power is zero. Motor action takes place at 180 deg., and the machine increases speed more until the 270 deg. point is reached, where motor action decreases to zero at 360 deg. or its equivalent, 0 deg.

The vertical half of the circle, marked "fast" in Fig. 6, represents the range where generator action takes place. The half marked "slow" represents the range where motor action takes place.

As has been mentioned earlier in this series, the maximum instantaneous current flowing when a machine is paralleled under abnormal conditions may rise to a much greater value than that shown in Fig. 6, owing to transient effects. Fig. 6 represents the general conditions for a machine being paralleled on a large system where reactance of the machine is high in comparison.

Engineering Features of a 2,000,000 KV-A OIL CIRCUIT BREAKER



By

A. W. HILL

Circuit Breaker Engineer
Westinghouse Electric & Mfg. Co.

RECENT YEARS HAVE SEEN a substantial increase in system interconnections which in the field of oil circuit breaker manufacture has resulted in designs for much higher ratings. For a number of years the 73,000 v., 1,500,000 kv-a. breaker has been adequate to handle any commercial installation. It was not until the Philadelphia Electric Company and other systems in the eastern Pennsylvania region became interconnected, with the possibility of great short circuit kv-a. at their Plymouth Meeting substation, that a breaker having a rating of 2,000,000 kv-a. was found necessary. Five breakers of such a rating have now been in service for somewhat more than 2 yr.

These breakers are of a more or less standard 3-pole construction outwardly, having a simple solenoid operating mechanism mounted 2 ft. off the ground on brackets welded to the side of the No. 1 pole. However, it was felt desirable to provide at the start for a possible future arrangement with the three poles independently operated, this change to be made as system operating conditions might show necessary. Therefore, additional brackets were provided on all three tanks of each breaker, so that it would require merely the addition of a solenoid of the proper size to each tank, without any major change involving machining or welding on the tanks in the field.

The tanks of this breaker are floor mounted, each containing slightly over 800 gal. of oil. It is apparent that the weight of one such tank filled with oil (which alone weighs 3 t.) is so great as to make it too cumbersome to be raised and lowered as in the familiar frame mounted breaker. Furthermore, the tanks are 58 in. in diameter and large enough to allow the use of a manhole in the top for access to the interior during periods of installation or maintenance. Being above the normal oil level, the gasket under the manhole cover is not subjected to oil leakage which is always objectionable from the point of view of appearance if nothing more. Each tank was given a hydrostatic pressure test before shipment from the factory to insure that it would be mechanically strong and at the same time oil and weather tight.

These breakers are equipped with condenser type bushings of the conventional design. They are slightly larger than those used on standard 69 kv. apparatus, in order to meet the requirements set up by the purchaser that they should have the following insulator characteristics:

Average dry flash-over (60 cycle).....265 kv.
One minute 60 cycle with-holding.....200 kv.

These flashover values are obtained with a porcelain weather casing approximately 30 in. in effective length but with rain sheds of such size that the surface creepage distance from the live parts at the top end to ground is 1.8 times the striking distance. It is a one piece porcelain made by the wet process coming from the kilns as a unit and, having no cemented joints, there is no chance for leakage of the filling compound.

The lower end of the bushing is of the butt end construction. This is the simplest and preferred design wherever space permits making this end of the bushing long enough to reduce the potential gradient over the surface to such a point that carbon will not be drawn out of the oil and become a hazard.

De-ion Grids Extinguish Arc

De-ion Grid contacts are used to extinguish the arc. In this design, the moving contact consists of a very simple arrangement of hard strap copper making a butt contact with a hinged stationary copper block, substantial in weight and backed up by a strong helical spring. Tests made with these contacts show a maximum temperature rise at 1200 amp., 60 cycles (held till temperatures became constant) of not more than 15 deg. C. and this rise is independent of the condition of the contacts, being no greater with contacts burned by a large number short-circuit operation, than when

considering new contacts. This is to be expected of course since both moving and stationary contacts are made of metal having better than 99 per cent conductivity, low contact drop, and such a good conductor of heat that the large masses of metal on either side of the contact point readily absorb the heat generated, passing it on by convection to the surrounding oil. Below the point of contact and part of the stationary contact, is suspended a stack of slotted plates, the moving contact being located in this slot when the breaker is closed, and passing downward and out the bottom end of the slot as the breaker is opened. The arc formed during an opening operation is confined within the slot of this stack. Spaced periodically throughout the height of the stack are soft iron plates, shaped roughly as a

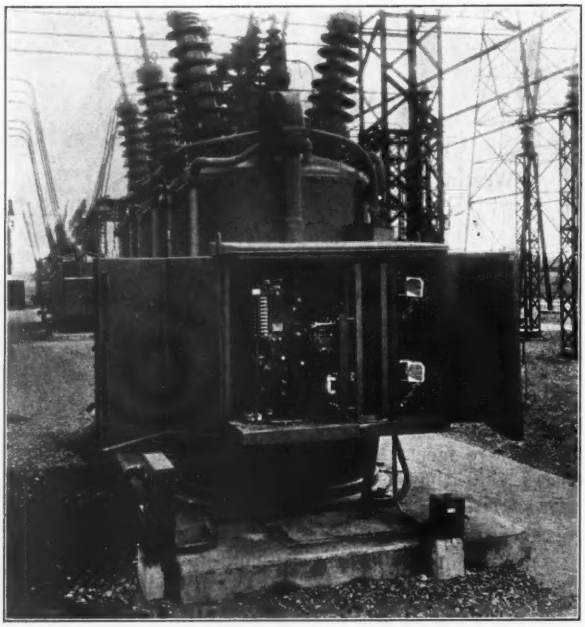


FIG. 1. THE 2,000,000 KV-A, 73 KV. BREAKER, INSTALLED AT THE PHILADELPHIA ELECTRIC CO.

horse shoe, which exert a magnetic attraction to the arc with the flux set up in them by the field of the arc itself. This force is directed horizontally outward from the center of the breaker, tending to drive the arc further back into the slot against the oil contained therein. In order that these iron plates shall not be burned by the arc, they are insulated all around by fibre plates.

Between these magnetic elements there is a vertical space which is filled with other insulating plates made of fullerboard, and so shaped as to include three oil pockets or "reservoirs" at the back end of the slot. As the arc is driven magnetically back into these reservoirs it is held in close contact with the oil because of the restricted space and the gases resulting from the decomposition of the oil can escape only by crossing horizontally through the arc. Thus by controlling the arc and gases in a predetermined manner, it is possible to bring about the extinction of the arc in a very short length and with a low value of arc voltage. Instead of allowing the arc to wander more or less aimlessly within a comparatively large bubble of gas, it is now controlled and the de-ionizing action of the cool oil and gases given an opportunity to act most favorably over the entire length of a short arc. As a result the breaker operates under short-circuit consistently with a short duration of arc, small depreciation of oil, and with little of the outward evidences frequently seen on breakers of other types.

Overall speed of operation of these breakers is of prime importance in order that system stability can be maintained under conditions of short-circuit. This time limit is set at 8 cycles (C. 133 sec.) measured from the instant the trip coil is energized till the arc is extinguished. It is obtained through the coordination of three design features: a strong accelerating spring compressed simultaneously with the closing of the breaker by the solenoid operating mechanism, a set of moving parts made light and streamline by the use of high strength materials, and a type of contact whose arc extinguishing action is inherently fast.

With the closing mechanism at the front end of the breaker assembly, it becomes desirable to locate the accelerating spring at the opposite end, so as to keep the connecting pull rods always under tension. The spring itself is made to operate under compression so as to avoid the use of hooked ends or special connectors which might give trouble under load. The spring is heat treated after winding, permitting its use up to that load which gives a maximum fibre stress of 90,000 lb. per sq. in. The final load of this spring is approximately 1400 lb. and it operates over ⅓ the contact travel, giving up its energy to the moving contacts until they reach a speed of the order of 15 ft. per sec.

The pole unit levers are largely made of steel strap and bar, welded together with their wide sections placed vertically to provide the strength where most needed and with the thin sections offering the least resistance to motion through the oil. Noncorrosive pins and bearings with brass washers between each two moving surfaces insure that friction will be kept to a minimum. Between the levers in the tank top and the moving contacts, are the lifting rods made of wood base Micarta. This material provides a maximum of mechanical strength for a given cross section and weight and at the same time an electrical strength which has never been equalled in commercial apparatus.

The breakers incorporating these features have been in continuous commercial service since the summer of 1930. During the two lightning seasons and intervening winter, the performance has been fully up to expectations, and in the operation of the system faults have been handled with a breaker speed such that outages of circuits other than the one immediately concerned have been avoided. In other words, the system has operated under conditions of stability, which was the underlying reason for applying circuit breakers of the rating and performance required to meet these specifications.

TEXTURE OF THE SURFACE of a sheet of rolled steel is different from that at the center of the sheet, says Dr. Francis Bitter, research physicist of Westinghouse Electric. This is due to the peculiarly distributed stresses immediately under the rolls, he says, and explains that the phenomenon is partly responsible for the fact that the outside layer of a rolled sample has different magnetic properties from the core.

How Fuse Troubles Were Eliminated

Thorough investigation of Fuse conditions in an industrial plant and establishment of a definite policy result in reducing fuse troubles 95 per cent.

By L. W. HAYWARD
Power Superintendent
Tennessee Copper Co.

AS THE DESIGN of motors and motor starters changes the problem of fusing motors also changes. In the past fuses were looked upon as the link in a motor circuit which would protect the motor from serious overloads, but today the temperature overload relay has taken the problem of overload protection away from the fuse, and is giving better protection than was ever possible with fuses. Reduced voltage and across the line starters from the fractional horsepower size to the 500 hp. or larger sizes are now equipped with adjustable temperature overload relays.

Fuse manufacturers have tried to keep pace with this change by improving the time lag feature in their fuses, but with the use of temperature overload relays the time lag in fuses is less important.

We, probably, are all acquainted with such fuse troubles as charred cartridges, loose contacts, dirty and burned contacts, hot switch boxes and the many methods of over fusing, even to the substitution of copper wire and nails for fuse links in extreme cases. Many of these troubles originate due to the installation of fused switches too small to protect against motor overloads. When this is done the operators are troubled with fuses blowing when the motors are started or when momentary overloads occur. During the starting period the motor current may be from two and one-half to seven times full load current of the motor, depending upon the type of motor, type starter and nature of load. The operator in charge puts in new fuses by refilling renewable cartridges or replaces with new cartridges already filled, but not being an electrician, he does not realize the importance of clean and tight contacts and before long the fuses are blowing due to internal heating caused by loose and dirty contacts. In his attempt to keep the equipment operating he often resorts to three or four extra links, or copper wire.

This was the condition found in our plant, and our investigation led us to the following conclusions:

1. Ninety-five per cent of all our fuse trouble was due to internal heating in fused switch boxes due to loose and dirty contacts.
   (a) Loose and dirty contacts were caused by operators not properly installing fuses.
   (b) Loose and dirty contacts due to lack of proper inspection and cleaning by Electrical Department.
2. The operators could not be blamed for over fusing and copper wire fuses, for had fuses of the proper size been originally installed they would not have had to resort to these methods to keep equipment operating.
3. An investigation was made to determine if certain makes of fuses were superior to others and if by changing fuses we could eliminate our fuse trouble. This investigation led us to believe that our trouble would be experienced with any make of fuse and that the fuse we were using had some advantage over other makes.
4. That fuses should not be used to protect motors against overloads as the temperature overload relay is far superior to fuses due to its current time feature and its ability to prevent motors from single phasing.
5. That fuses should be used only to protect the starter, lines and motor against short circuits and abnormal currents, and that fuses should be large enough so they will not blow under momentary overloads, or during the motor starting period.

With these conditions established we inspected all our fused knife switches and renewed all weak contacts, cleaned all blades and contacts, cleaned and refilled all fuses. On switches which had fuses too small to carry the starting current of the motor, but large enough to carry full load motor current, two links were put in each cartridge. On each switch box was painted the sign "single fused" or "double fused" to show the fusing desired. On each cartridge was pasted a gummed seal marked "single" or "double". This gummed seal was put on so in case the fuses were taken apart the seal would have to be broken. This seal serves three purposes:

1. To tell whether there are one or two links in the cartridge.
2. To tell if operator has had to refill fuse due to blowing.
3. To tell if cartridge is heating. If cartridge heats the gummed seal will turn brown.

At the time of repairing switches all overload relays were cheeked for proper setting in starting panels.

After ten months of operation we find that 95 per cent of our fuse trouble has disappeared; our switch boxes are now cold where they used to be hot; our operators do not have to resort to improper fusing to keep the process going; and the saving resulting from the elimination of fuse renewals and shut downs, has paid for our efforts many times and in addition we feel our motors are better protected than they ever were before.

THREE METHODS for increasing domestic use of power to raise the standard of living and cut down cost of household operation are under consideration by the N. E. L. A. and were discussed at Atlantic City recently. These are: A promotional rate for power as used for refrigeration, cooking, ventilation and heating; reduction in cost of domestic appliances; better demonstration and selling of the economies of household electrification. The goal is an average of 2000 kw-hr. a year per household as against present use of 578 kw-hr.

POWER PLANT ENGINEERING September 1932

Cavitation—

Its Cause and Influence on Hydraulic Turbine Design

Cavitation has long been a source of trouble and mystery to designers of hydraulic turbines and pumps. With the development of high specific speed propeller turbines and centrifugal pumps, cavitation becomes a limiting factor affecting design for maximum capacity and causes considerable damage to runners. For these reasons, the abstract of the discussion on Cavitation by Professor Spannhake before the Hydraulic Power Committee of the N.E.L.A. presented here, should be of interest not only to designers but to users of turbines and pumps as well. Cavitation it is shown is much more of a physical than a chemical problem. ¶ Professor Spannhake of the Technische Hochschule, Karlsruhe, Baden, Germany, now visiting professor of hydraulics at M. I. T., is continuing his experiments on cavitation at this institution.

In the formula which Professor Spannhake has developed, the coefficient E offers an approximate measure of the elements conducive to cavitation, but there is need of more critical study of other influences in order that the results of laboratory tests may be correctly translated to apply with certainty to the prototype. Studies indicate three methods of avoiding cavitation, first by design of turbines to operate with forward whirl in the draft tube, second by improved distribution of pressure along the back side of blades and third, by use of a blade profile having its forward edge shaped more advantageously.

THE SPRING MEETING of the Hydraulic Power Committee of the N. E. L. A. was marked by two unusual and valuable discussions by eminent authorities, one a discussion of paints and protective coatings by Prof. Colin G. Fink of Columbia University and the other a discussion on the subject of "Cavitation" by Prof. Wilhelm Spannhake of Technische Hochschule, Karlsruhe, Baden, Germany, now visiting professor of hydraulics at the Massachusetts Institute of Technology. The phenomenon has caused much trouble in recent years in turbines of relatively high specific speed. Prof. Spannhake's discussion covered practically the entire range of knowledge and research on the subject up to date and he outlined various phases of the problem concerning which further research must be had in order to understand the problem completely. In this article we present a brief abstract of this paper but the discussion has been published complete in N. E. L. A. Publication No. 122.

In presenting his discussion Prof. Spannhake first referred to some of his early experiences, connected with this subject. About 1899 at the Joice Electric Power Plant, Bosnia, the high head turbine showed destructive effects on the blades of the runner. These blades were shaped about as shown in Fig. 1. The destructive effect it will be seen occurred on the back or low pressure side of the blades. In another instance, that of a German torpedo boat, the effect was noticed on the "pushing" side of the blade.

"In 1918," said Prof. Spannhake, "I tried to investigate this question by some tests in a small glass covered box in which a blade about like an airplane profile was mounted as in Fig. 2. The blade was to simulate the entrance of the flow into the blading of the turbine and I experienced the same destructive effect even on the glass plate covering a part of the box. These effects seemed to be caused by very high pressures. Since that time the subject of cavitation has become a problem of widespread interest.

"What is cavitation? The name itself tells. If in any flow, closed or open, a cavity or void filled with air, gases and fluid vapor is formed, then we have cavitation.

"How can this void be generated? Pure water can stand tension. In fact, absolutely pure water can stand tension to a surprising degree. On occasions water has been subjected to a tension of over 20 atmospheres. This is possible only if there is no air or other foreign matter in the water.

Of course, our turbines are not running with pure water, but water that is mixed with solid matter and at least some air and gases. In this case when the pressure at a point drops to a certain value, the coherence of the water is broken and the gases freed from the water. A bubble or series of bubbles is generated and these bubbles assist in starting the vaporization of the water.

"Now, at what points in the flow can the pressure drop to that of the vapor pressure of the fluid? Theoretical considerations and experience tell us that if there are no vortices in the fluid, the point of lowest pressure can occur only on the boundaries of the flow, that is to say, on the solid walls no matter whether these walls are standing still or moving in the fluid. But in case there are vortices, the lowest pressures—as far as the neighborhood of the vortices is concerned—are generated in their centers. Their voids can become very much drawn out, and the center of a vortex filled with air can extend either down stream or even across the flow. I remember a beautiful effect which appeared during an experiment with a weir in a flume being tested in an hydraulic laboratory. The weir was formed as in Fig. 3 with water entering the weir box near the bottom at one side, so that there was in the forebay above the weir a distinct roll. Therefore, a certain amount of rotary velocity was in the flow as it approached the weir crest, and as such motion follows as far as the rotary components V_u are concerned the law $V_u \times r = \text{constant}$, these tangential components become, therefore, very high, especially near the center of rotation. The pressure according to Bernoulli's equa-

tion drops to the point that we have a void filled with air, oscillating up and down the nappe, but on the whole very stable and with the upstream end as indicated.

"Now, a similar case of potential cavitation occurs in the majority of our turbines and pumps if there are peripheral components in the flow as of course happens very often. It is not at all possible to have purely axial flow in draft tubes and I think that it is this phenomenon that sometimes causes oscillations in the output when the unit is on the line. A few weeks ago I was told that the conditions in such a case were much improved by putting radial fins in the draft tube lines, as shown in Fig. 4.

"In the Kaplan turbines the guide vanes are sometimes arranged as shown in Fig. 5. The guide vanes overhang the curb ring leaving a small space below the vanes. So below the vanes a small space is formed which in vertical section is as shown in the auxiliary view 4(a). Eddies are formed with their axes about

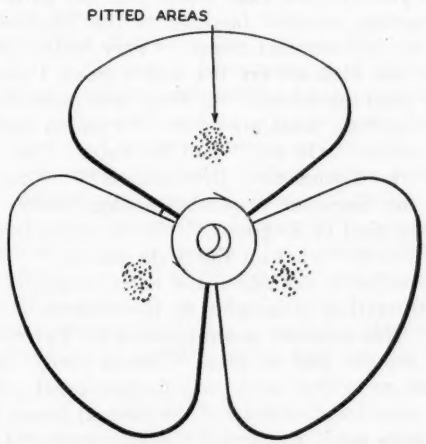


FIG. 1. PITTED SPOTS ON PROPELLER OF TORPEDO BOAT

as shown by the dotted lines in both 4(a) and (b). In the region where the pressure is still high they do no harm but if the vortex extends into a region of low pressure a void is generated. This void with the eddy then passes over the wall of the casing, and if it comes again into a higher pressure, it collapses suddenly with consequent shock to the wall. This action, it has been shown, results in damage to the wall.

"If at any point the absolute pressure approaches the vapor pressure, air and gases are liberated from the water and the first stage is the generation of a small bubble. Now as this bubble grows it is either shifted down stream as a whole or else it expands so much that one end of this bubble again reaches a zone of higher pressure. Then the fluid vapor is condensed suddenly since the process of vaporization and condensation are really reversible, but the reabsorption of air does not take place as readily. The surface of the bubble to which the air is exposed is so very small that in the exceedingly short time the gas cannot go back into the fluid and be dissolved again. This small bubble of air is compressed by the impact of the collapse in an infinitesimally short time. The volume itself being so small, the ratio between the volume after compression and that before the beginning of this effect is very high so that tremendously high pressures result. Rather rough approximations have shown that it is possible to create about a thousand atmospheres; and another very important thing is that this small bubble of gas, or air, so compressed can enter a small crevice or cleft in the material. If the bubble happens to strike and lodge in such a crevice in the material, it can act like an explosive and be destructive. The effect is very dangerous and it is the real reason for the rapid breaking

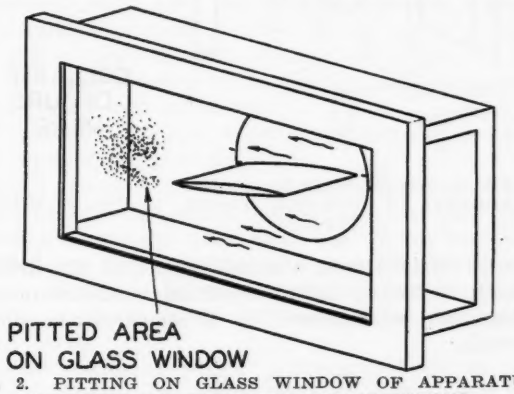


FIG. 2. PITTING ON GLASS WINDOW OF APPARATUS DESIGNED FOR THE STUDY OF CAVITATION

up of the material caused by cavitation. All other effects are secondary. Physical and chemical effects are, in my opinion, absolutely of minor importance even though they are too important in many instances.

"It is not yet possible to offer an exact theory for all these phenomena because they are very complicated. The effect may produce great turbulence, aggravated by the generation of cavities. The destruction depends on the elasticity of the materials and of the water itself, and on the yield point of the materials. Materials having the higher resiliency like bronze are supposed to stand this effect better than those that are brittle like glass. Much also depends on the heat conductivity of the materials and the water. The compression of this small amount of gas or air having so small a surface and in so short time is a process that is certainly not isothermal, but is either adiabatic or polytropic. Thus an increase of temperature is possible. This, perhaps, explains the curious looking effect on the damaged surface that makes it look like melted lava."

The foregoing contains Professor Spannhake's theory of cavitation in simple language. As he explained, the experimental basis for all these phenomena is not yet

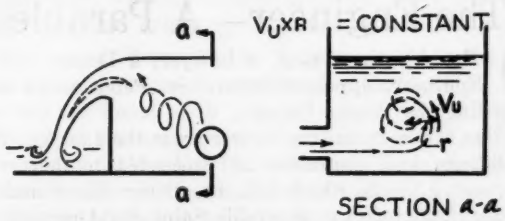


FIG. 3. CAVITY IN FREE NAPPE OF A WEIR, RESULTING FROM CIRCULATION OF WATER IN FOREBAY

so broad as to afford at this time an exact physical or mathematical theory. He did, however, discuss the effects of Reynold's number which expresses the ratio between the influence of inertia forces and the influence of internal friction in the fluid caused by viscosity. This ratio is of great importance in studies of cavitation in models and Professor Spannhake discussed test

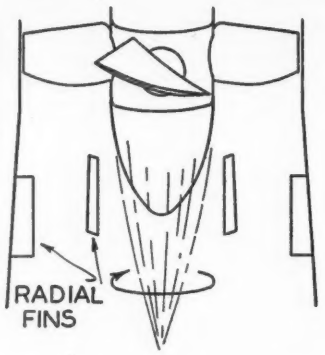


FIG. 4. RADIAL FINS TO MODIFY VORTEX IN TURBINE DRAFT TUBE

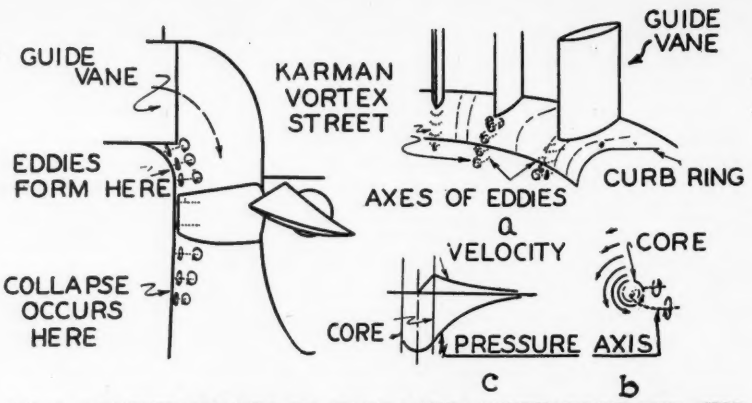


FIG. 5. VORTICES FORMED BY GUIDE VANES OVERHANGING THE CURB RING OF A TURBINE

results obtained from a model and a full size turbine. Finally he showed that the conditions conducive to cavitation can be expressed by a comparatively simple formula:

$$E = \frac{H_b - H_v - H_s}{H_t}$$

where H_b is atmospheric pressure
H_v is the vapor pressure
H_s is the static suction head, and
H_t is equal to the total head.

The theoretical basis for this formula was presented in a curve which showed the progressive changes in pressure on a particle of water while flowing through a turbine.

The coefficient E in the above formula offers an approximate measure of the elements conducive to cavitation, but as Professor Spannhake pointed out, there is need of more critical study of other influences in order that the results of laboratory tests may be correctly translated to apply with certainty to the prototype. Studies indicate three methods of avoiding cavitation: first by design of turbines to operate with forward whirl in the draft tube, second by improved distribution of pressure along the back side of the blades, and third by the adoption of a blade profile that will have its forward edge shaped more advantageously.

The Engineer—A Parable

ONE DAY three men, a Lawyer, a Doctor and an Engineer, appeared before St. Peter as he stood guarding the Pearly Gates.

The first man to step forward was the Lawyer. With confidence and assurance, he proceeded to deliver an eloquent address which left St. Peter dazed and bewildered. Before the venerable Saint could recover, the Lawyer quickly handed him a writ of mandamus, pushed him aside, and strode through the open Portals.

Next came the Doctor. With impressive, dignified bearing, he introduced himself: "I am Dr. Brown." St. Peter received him cordially. "I feel I know you, Dr. Brown. Many who preceded you said you sent them here. Welcome to our City!"

The Engineer, modest and diffident, had been standing in the background. He now stepped forward. "I am looking for a job," he said. St. Peter wearily shook his head. "I am sorry," he replied; "we have no work here for you. If you want a job, you can go to Hell." This response sounded familiar to the Engineer, and made him feel more at home. "Very well," he said; "I have had Hell all my life and I guess I can stand it better than the others." St. Peter was puzzled. "Look here, young man, what are you?" "I am an engineer," was the reply. "Oh yes," said St. Peter; "Do you belong to the Locomotive Brotherhood?" "No, I am sorry," the Engineer responded apologetically; "I am a different kind of Engineer." "I do not understand," said St. Peter; "what on Earth do you do?" The Engineer recalled a definition and calmy replied: "I apply mathematical principles to the control of natural forces." This sounded meaningless to St. Peter, and his temper got the best of him. "Young man," he said; "you can go to Hell with your mathematical principles and try your hand on some of the natural forces there!" "That suits me," responded the Engineer; "I am always glad to go where there is a tough job to tackle." Whereupon he departed for the Nether Regions.

And it came to pass that strange reports began to reach St. Peter. The Celestial denizens, who had amused themselves in the past by looking down upon the less fortunate creatures in the Inferno, commenced asking for transfers to that other domain. The sounds of agony and suffering were stilled. Many new arrivals, after seeing both places, selected the Nether Region for their permanent abode. Puzzled, St. Peter sent messengers to visit Hell and to report back to him. They returned, all excited, and reported to St. Peter:

"That Engineer you sent down there," said the messengers, "has completely transformed the place so that you would not know it now. He has harnessed the Fiery Furnaces for light and power. He has cooled the entire place with artificial refrigeration. He has drained the Lakes of Brimestone and has filled the air with cool perfumed breezes. He has flung bridges across the Bottomless Abyss and has bored tunnels through the Obsidian Cliffs. He has created paved streets, gardens, parks and playgrounds, lakes, rivers, and beautiful waterfalls. That Engineer you sent down there has gone through Hell and has made of it a realm of happiness, peace and industry!"

*By D. B. Steinman, President of the New York State Society of Professional Engineers, and Past-President of the American Association of Engineers. Reprinted from the "The American Engineer" for January, 1932.

Station Piping*

BASED on operating experience of 35 companies with piping, fittings and valves up to pressures of 1500 lb., the report deals with welding of piping, steam velocities, joints, expansion, bends and finish for pipe covering. In the original report, details of experience in each plant are briefly stated and the summary is as follows:

Pipe Welding

Field welding is increasing, using both electric and gas systems, some preferring one, some the other and some using both systems according to the nature of the work. Some preponderance in practice would seem to be on the side of acetylene gas welding.

For smaller sizes, economy of welding vs. screwed flanges and fittings seems to vary, but the higher the pressure, the smaller will be the pipe size on which welding shows good economy, largely because of reduced maintenance cost. Other factors that enter are, number of joints, space, availability of welding equipment and experienced operators.

Butt welding has been used up to 425 lb. at 750 deg. F. but, in the main, for pressures of 600 to 1500 lb., flanges are screwed and welded to the pipe and the joints made with metal gaskets or by welding the flange rims. Forged-steel, screwed sleeves and fittings, welded solid are also used for small high-pressure piping.

Few failures are reported, mostly detected during tests, the others being due to excessive temperature changes, bad piping support or poor workmanship.

Economy is reported of 20 to 60 per cent over flanged construction, depending on size of piping and conditions of erection, time saving being a considerable factor in most cases. Cost of maintenance is less for the welded systems.

High Pressures

For pressures above 1200 lb., asbestos gaskets in joints of small piping and in valve bonnets have been replaced by metal gaskets of Monel, steel or soft iron. Sarlun type joints have given no trouble but tongue and groove joints have been troublesome.

Valve Seats and Discs

For higher pressures and temperatures, nitrided steel or Nitralloy is reported satisfactory for both steam and water service. With medium pressures, Monel for steam and stainless steel for water have given good service. For low pressures and temperatures in water lines, hard bronze has been much used.

High Steam Velocities

To reduce the initial cost of piping, high velocities are employed, one station reporting 34,000 ft. per min. in a line for emergency supply to the low-pressure turbine when the high-pressure end is out of service. So extreme a velocity caused breakage of thermometer wells and great wear on throttle and governor parts but stronger wells and redesign of parts corrected the trouble. Velocities of 6000 to 17,000 ft. per min. have worked satisfactorily although, in two cases, some vibration ensued. With velocities of 16,800 to 34,000 ft. per min., vibration, wear of parts and thermometer well breakage were encountered.

Several companies use the rule of 1000 ft. per min. for each 1 in. of pipe diameter but it appears that, for over 16,000 ft. per min., great care must be exercised in the design of the piping and appurtenances to prevent vibration and wear.

*From Prime Movers Committee Report No. 217 of N. E. L. A.

Joints and Gaskets

Sarlun, Sarjol and Van Stone joints are used for steam piping over 2 to 4 in. diam. for pressures above 400 lb. in most stations. The first two are welded at permanent joints, while for valves and branch headers metal gaskets are used. For 1¼ to 2-in. piping, tongue and groove joints are most common; for under 1¼-in., also for high-pressure water piping, large male and female joints with metal gaskets.

From 600 to 1200 lb., asbestos and sheet gaskets have been replaced by metal gaskets.

On 3 non-return valve bonnets, having nuts made from a hexagon bar, bored, threaded and case hardened, several nuts cracked after brief use. When made as specified by cold punching and case hardening no trouble developed. It was thought that failure of the bored nuts was the result of grain being the wrong way of the metal.

Some companies prefer pilot-operated valves for drainage control, especially where large volumes of water are to be handled and pressure drop across the valve is high. Others choose the direct-acting valve but one company feels that the ordinary port opening is too small. Troubles were encountered from floats, from sticking of rods and from cutting of seats.

Expansion and Bends

With temperatures above 350 deg., some difficulty has been met with copper expansion joints but was remedied by using Monel sleeves to reduce wear, limit leakage and reduce temperature of the copper. Where alinement is poor, packed joints have given some trouble but, properly installed they have been satisfactory, particularly where expansion and contraction are frequent.

Above 200 deg., rubber joints show too little endurance; in some cases, failure from insufficient strength was reported for rubber joints 24 to 66 in. diam.

For bends, minimum radius depends on thickness of the pipe wall, varying from 3 to 5 times the pipe diameter. Specifications call for bends on radii given, true to form, free from buckles, creases and flat spots and with tolerance in diameter from 1/16 in. for 3-in. pipe to ¼ in. for 20-in. pipe, or 1½ per cent over or under standard size. Wall thickness to be no more than 15 per cent under normal thickness specified. Flanges must be faced at right angles to the center line of the pipe.

Non-Return Valves

Used singly, these have performed admirably but, when two are installed in parallel, careful operation is required to avoid uneven heat distribution in the superheater, particularly while the boiler is being brought up to pressure. Two companies have settled on the use of one non-return valve controlling the single boiler outlet.

Finish for Pipe Covering

For finishes on canvas before paint is applied, glue has been successful, also a mixture of varnish and paint and aluminum paint with no filler. Silicate of soda has been satisfactory in some cases, in others not, while one company has found no filler or paint that would not peel off the cover of high-pressure piping.

Others use asbestos sealer or regular lead-base paint and have no difficulty.

Sikeston Municipal Plant Rapidly Builds Load

Missouri Municipality Builds Diesel Engine Plant in 1931 with $150,000 Bond Issue. Dan G. Pepper, Superintendent

IN APRIL, 1930, the city of Sikeston, Mo., voted a bond issue of $150,000 for the construction of a municipal power plant and distribution system. In November of the same year Fairbanks, Morse & Co. received the complete contract for a total price of $123,600. This bid included two 600 hp. engines, generators and auxiliary equipment, building, fuel storage tanks, cooling tower, white way, switchboard and complete distribution system. Subcontracts for the building and fuel tanks were let to J. A. Sutterfield Const. Co. and for the distribution system to R. H. Bouligny, Inc. The original survey and engineering work was carried out by W. A. Fuller & Co. Including an item of about $15,000 for office equipment, engineering and interest during construction, the complete system as of Dec. 31, 1931, was carried on the books as $163,540.89.

When started on May 19, 1931, the plant had only the street lights. Customers were added rapidly, however, and at the end of the year, that is, the first six months of operation the plant was supplying 1085 customers. The remaining 150 potential customers were still supplied from the older system of the Missouri Utilities Co.

At the end of this period the plant showed a gross operating profit of $13,570.90 or after an allowance of $7,500.83 for depreciation and interest a net profit of $6,070.07. Based on the month of November as an average normal month, the yearly net profit would be about $27,000.

Rates, the same as those of the utility company prior to the construction of the municipal plant, range from a maximum of $0.09 down to $0.03 per kw. hr. for domestic service and from $0.07 down to $0.02 per kw. hr. for commercial power. Production cost to the switchboard for this period averaged $0.00749 per kw. hr. and for distribution $0.00334, giving a total cost of $0.01083 per kw. hr. delivered. Some 650,069 kw. hr. were sold, the distribution losses averaging about 8.5 per cent of the total generated.

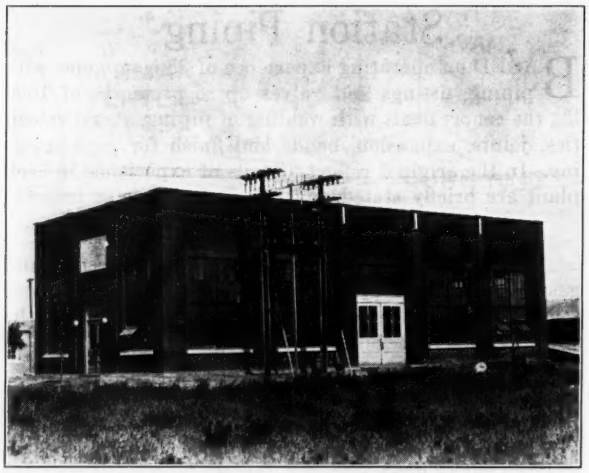


FIG. 1. EXTERIOR VIEW OF PLANT

Cost of the plant and distribution system is shown by Table I and the operating expense to date in Table II.

TABLE I. COST OF THE COMPLETE PLANT AND DISTRIBUTION SYSTEM AS CARRIED ON THE BOOKS DEC. 31, 1931:

Account	Amount
Plant Structures	$ 12,750.00
Fuel Holders	1,111.33
Engines	58,187.00
Electric Plant	8,342.49
Misc. Plant Equip.	3,497.68
Poles, Towers and Fixtures	19,905.56
Transmission Lines	21,321.96
Line Transformers	10,083.36
Meters	12,119.42
Office Equipment	1,917.62
Truck Equipment	823.00
Engineering & Supt.	6,704.66
Law Expenditures	1,599.94
Interest on Bonds during Const.	5,176.87
	$163,540.89

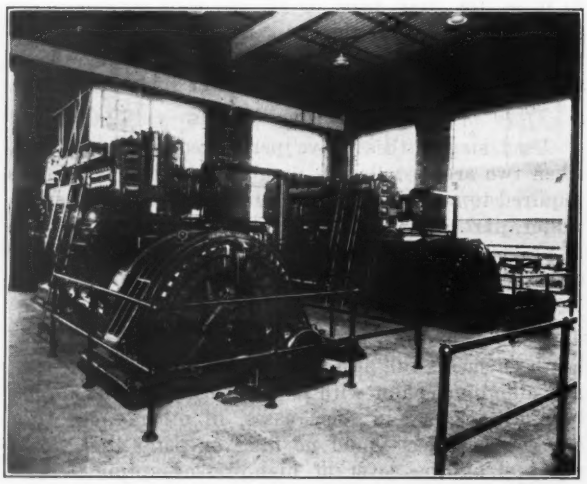


FIG. 2. TWO 600 HP. 4 CYLINDER ENGINES ARE INSTALLED

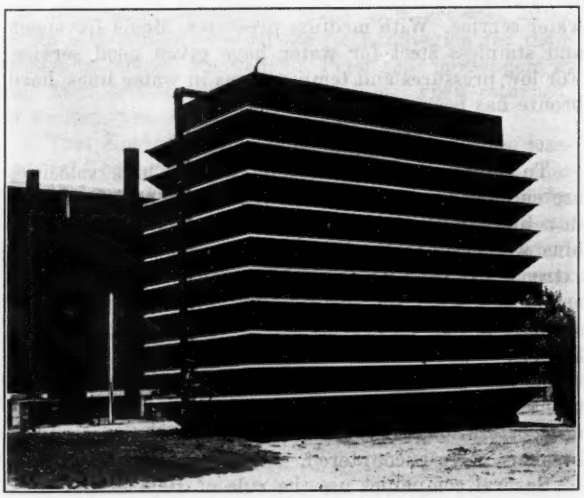


FIG. 3. A COOLING TOWER COOLS THE WATER JACKET

TABLE II. EXPENSES OF OPERATION AND DISTRIBUTION

Production Costs	May 19, 1931 to Dec. 31, 1931		Jan. 1, 1932 to June 30, 1932	
Superintendence	$ 825.00		$ 500.00	
Engine labor	2,525.80		1,720.00	
Fuel	3,567.75		1,932.03	
Miscellaneous	35.17		.....	
Water and Chemicals	107.21		65.59	
Lubricants	1,082.81		635.33	
Supplies	127.68		223.54	
Station expense	28.30		94.99	
Maintenance				
Station buildings	32.15		76.56	
Fuel holders	72.00		29.18	
Engines	103.77		365.70	
Exciters	15.22		64.87	
Miscellaneous	105.86		15.25	
Total production	$ 8,628.72	$ 5,723.04		
Distribution and miscellaneous				
Operation	1,952.36		2,011.01	
Maintenance	386.85		335.70	
Office and commercial	3,732.68		1,752.12	
Merchandising	599.31		687.23	
Insurance	494.43		361.65	
Regulatory commission	164.80		.....	
Depreciation	4,046.94		3,438.83	
Interest	4,135.31		4,135.31	
Total	15,512.68	12,721.85		
Total expense	$24,141.40	$24,141.40	$18,444.89	$18,444.89
Total Revenue		$33,718.23		$28,472.92
Net Profit		9,576.85		10,028.03
Total Profit, May, 1931-June, 1932				$19,604.88

OPERATING RECORD TO DEC. 31, 1931.

Total generated, kw. hr.	1,112,475
Total sold, kw. hr.	1,045,727
Distribution loss	66,748 or 6 per cent
Total fuel, gal.	101,350

In addition to the engines, the plant has a 22,500 gal. underground concrete oil storage tank, a 30 kw. gasoline engine driven exciter, a 500 g.p.m. Schubert-Christy cooling tower, and a Westinghouse 8 panel all steel switchboard. Exciters are all separately driven. Air compressors, DeLaval centrifugal, transfer pump and other auxiliaries are in an auxiliary basement. The present building is large enough for two additional engines.

Dan G. Pepper, Member of the Board of Public Works, is superintnedent and Harold D. Buckner is chief engineer.

Peeking

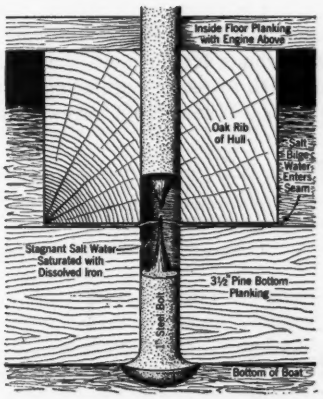
WHETHER seeking the much talked of corner around which lurks prosperity or pushing straight on in the path that leads to rising ground, it is heartening to note the signs that Miss Prosperity is peeking at us and showing signs of receptivity to those who come ardently wooing. Here are some of the indications which affect directly the power plant field:

A new power plant for Gartmann Baking Co., Latrobe, Pa.; three steam turbine units for Passaic, N. J., and two for Garfield, N. J., plants of Julius Forstmann Co., with boilers, superheaters, air heaters, water-cooled furnaces for pulverized fuel; steam distribution system for Treasury Dept., Washington, D. C.; motors and pumps for Quincy, Mass., plant of Standard Oil Co.; modernization of power equipment by Alpha Brush Co., Troy, N. Y.; municipal power plant and distribution system for Piqua, Ohio.

Indications of need for supplies and reëquipment in the near future are starting up and increase of activity in factories engaged in all lines of manufacture, over 50 individual cases being reported in the first part of August. Yarnall-Waring Co. reports June and July sales the largest since September, 1931, and Dodge reports show a definite upturn in engineering construction since midyear. In the flour milling industry, as in many others, the smaller plants are coming back and new equipment is being installed to care for increasing business, with Diesel engines and electric drive largely replacing the out-of-date steam plants.

Engine Bolt Corrosion

AFTER ABOUT 2 yr. operation it was noticed that the engine of the motor lighter Osprey in New York Harbor was loose on its bed. Investigation showed that a number of the engine-bed bolts had entirely corroded through at the joint between the bottom planking and the lower face of the ribs. As shown in the illustration, this joint is continually saturated with bilge water lying on the inner surface of the bottom planking. All the bolts were corroded in the same manner at the same point, several being completely separated with the engine held in place simply by friction of the bolt in the hole in the planking.


Inside Floor Planking with Engine Above
Oak Rib of Hull
Salt Bilge Water Enters Seam
Stagnant Salt Water Saturated with Dissolved Iron
3½" Pine Bottom Planking
Steel Bolt
Bottom of Boat

SHOWING THE CORROSION OF THE 1 IN. ROLLED STEEL BOLT AFTER 2 YR. SERVICE

The exact mechanics of this form of corrosion are difficult to define correctly. The degree of corrosion indicates an excessive rate accelerated either by galvanic action or by concentration cell corrosion. If the latter it would indicate that the uncorroded adjacent sections of the bolt were rendered cathodic and the corroded portion anodic.

It is also possible that stray currents from electric circuits of the main engine or auxiliaries may have been an accelerating factor. At any rate, the condition is one very frequently found where steel bolts are used for holding down engine bed plates in salt water craft where bilge water cannot be completely kept away from the bolts. The Osprey was fitted with new Monel Metal bolts which it is expected will completely eliminate recurring expenses of this kind as numerous records show that these bolts have been in service from 10 to 12 yr. without corrosion.

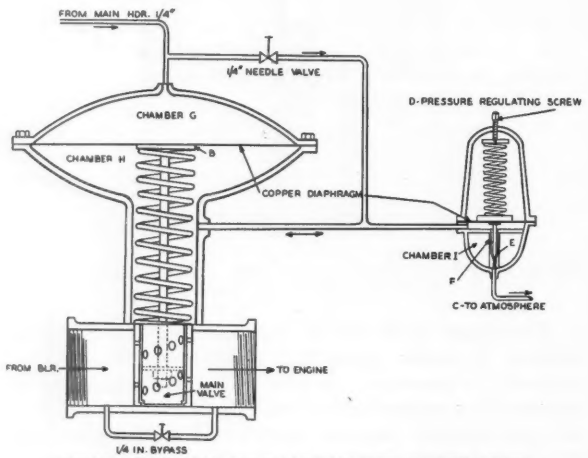
DATA collected by the Bureau of the Census shows that in 1931, 42 manufacturing establishments sold 1504 Diesel and semi-Diesel engines with a value amounting to $13,507,781. Both the number of units and the value are about 50% of that of 1929. In 1931 the total rated horsepower was 307,262, an average of 203 hp. per engine, as compared with the total output of 485,327 in 1929, the latter average being only 135 hp. per unit. About one-third of the total output is for marine purposes for direct connection to propeller shafts.

Readers' Conference

Troubles Experienced with Fan Engine Regulator

IN THE SKETCH is illustrated a regulating valve for a stoker fan engine and some of the things that I have found that cause it to give faulty regulation or to stop working completely. As may be noted, steam from the source to be regulated comes through the ¼-in. pipe to the regulator. Chamber G has at all times the same pressure as the source of supply. From this pipe the steam passes through a ¼-in. needle valve, which is used to regulate the engine speed between maximum and minimum.

For instance, if you carry 110 lb. gage and wish to keep the steam from varying more than 2 lb. this valve in conjunction with pressure regulating valve D, is used for that purpose. When D is screwed down to the



CROSS-SECTION OF FAN ENGINE REGULATOR

desired pressure, pin valve E seats, stopping the discharge of steam through pipe C, equalizing the pressure in chambers G and H, allowing the spring in chamber H to open the main valve in the steam line to the engine which will operate at the speed for which the governor is set until the steam pressure rises to the point where the pressure in chamber I overcomes the resistance of the spring under regulating screw D, thus opening valve E and allowing steam to escape from chambers H and I in sufficient amount to reduce the pressure in chamber H, thus allowing the pressure in chamber G to close the main valve slowing down the engine which is kept from stopping by use of the ¼-in. bypass around main valve. When the ¼-in. needle valve is properly adjusted, steam may be held to within 1 lb. of a designated pressure but when things start to go bad, they can furnish excitement aplenty.

One frequent cause of trouble is the clogging of the needle point valve as the opening of this valve when opened ½ to ⅞ of a turn of the spindle, is not large. Usually shutting and opening a few times will clear it but, after which it has to be set for the variation allowed. Another source of trouble is the cracking of the copper diaphragms. When this happens there is no regulation at all and the engine must be controlled by hand until repairs can be made. The regulator is installed in a bypass so that it can be shut off and removed from the line, the engine being operated by the regular throttle.

This usually keeps the operator busy, especially if carrying an irregular power load on the boilers. The latest trouble found, was in connection with part B, in chamber H. The regulator failed to open up when steam demands called for more fan speed. Everything usual was tried but, without success. On opening up, part B, which is screwed on to main valve stem, was found to have backed off the stem far enough to hold main valve shut.

Another source of trouble with these valves when first introduced, was with the waste pipe C. With several of these regulators they connected this pipe to the exhaust pipe of the engine. They never would regulate that way but as soon as given a free vent they functioned perfectly. Also, the line from main header was installed in one case so that water pockets were formed in the line. Taking these out remedied that cause of erratic performance.

Minneapolis, Minn. FRED S. RUTLEDGE.

Care and Installation of Ball Bearings

PRACTICALLY every machine and piece of equipment installed today has ball or roller bearings which, if they are to give the service for which they were designed, must receive the proper care and attention. This usually falls to the lot of the master mechanic or the plant engineer. In manufacturer's shops an arbor press is the best method of pressing the bearing on the shaft and in many cases this can be used during construction as most plants today have a sizeable machine shop. With a long shaft, however, this is not always convenient, and the oil bath method must be substituted.

With this method, the bearing is first expanded in a bath of hot oil and then shrunk on the shaft. The oil should be at a temperature of from 300 to 350 deg. F. and should be heated with hot water or steam coils because the danger of a fire with oil heated to this temperature is considerable. The handiest way is to start the bearing over the shaft with gentle taps of a light hammer and then drive it home with a length of pipe slipped over the end of the shaft.

The bearing must be started square on the shaft and the pipe must be cut off square so that the driving force will be even around the entire circumference. The pipe must not be large enough so that it will strike the outer ring because this would throw the bearing out of adjustment. A ring of tempered steel such as that of which the inner ring is made is easily cracked and to avoid this danger a wooden or lead mallet should be used to drive the pipe. If one is not available a piece of wood held over the end will deaden the blow.

Bearings are shipped from the factory all cleaned, oiled and adjusted ready for service and should be unpacked carefully so that they do not pick up dirt and have to be cleaned. The bearing must be the proper size for the shaft and the latter must be straight and round, also clean. The shoulder should be straight and clean with rough edges smoothed up with a file or emery cloth. Both filings and emery dust are sources of danger and must be watched with care. The particles are extremely abrasive. The best way to remove them is with an oily rag. This picks up the particles, oils the shaft and also forms a film which makes the remaining pieces visible.

When bearings have to be cleaned and when they are removed for inspection or replacement, the easiest method is first to wash them in a solution made with a cup of washing soda in a bucket of boiling water. After washing and removing all dirt they should be dipped in kerosene to rinse all particles out and then dried with air. Ordinary air from the air hose is not recommended because it contains considerable moisture; a small hand blower either with or without a nozzle is the best. After this they should be oiled or greased with a neutral lubricant. If they are not put back in service immediately they should be packed in a moisture and grease proof wrapper and stored in a dry place.

Brooklyn, N. Y. PAUL F. ROGERS.

Method of Keeping Oil Sample Bottles Clean

RECENTLY while on a vacation I observed two linemen securing oil samples from distribution transformers on a high voltage suburban and rural distribution system. Their system of assuring that their sample bottles would be entirely moisture proof was certainly worthy of consideration. They started out with a case of oil bottles each filled completely with clean tested transformer oil. Whenever they took an oil sample the bottle was first emptied into the transformer. This gave the neck of the bottle a thorough rinsing and avoided errors that sometimes occur due to moisture on the neck and cork of an empty bottle. They also pointed out that with small distribution transformers it was not good practice to rob the transformers of oil, as sufficient oil for three oil tests will often lower the oil level from a safe level to a hazardous level. This pair of men, however, carried plenty of oil along in sealed tins to supply any transformer with needed oil as well as new gasket material and glue for covers when needed.

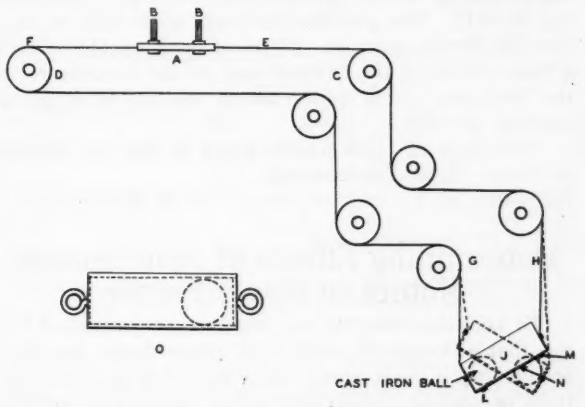
Iron Mountain, Mich. L. W. WYSS.

Remote Control of Shifting Belts

FRICTION COUPLINGS and electric motors have put out of business many shifting belt power transmissions, yet many such belt drives are still in use, some of which are necessarily located in such crowded or inaccessible places that it is often inconvenient to get to and operate the usual lever which actuates the belt shift. Sometimes it is desirable to operate a belt shift from a more or less distant part of a factory and occasionally it is desirable to be able to operate the belt shift from two or more parts of a room or factory.

Necessity drove the writer to rearrange a rope actuated belt shift in such a manner that the belt could be operated either "on" or "off" from any point where the rope could be grasped. After some experimenting a satisfactory belt shift control was devised, using a single weight in the form of a ball enclosed in a box or a cylinder to hold the belt in the desired position. To more fully understand the manner in which the shifting ball operates, it may be well to examine the accompanying sketch in which the shifting bar is shown at A.

Pins which move the belt are shown at B and the sheaves C and D permit ropes E and F to pass downward or laterally, as the case requires, and other pulleys bring the ropes side by side, as shown at G and H. At the extreme station, the rope loops around a rectangular box J which is made to lie at an angle of about 45 deg. The box should be made of such length that the 45 deg. inclination will be maintained with the shifter bar



REMOTE CONTROL BELT SHIFTER

in either the working or the idle position. A cast-iron ball from 5 to 7 in. in diameter is to be placed inside of the rectangular box J, which is made of such width and thickness as to permit the ball to roll freely inside of the box. The rope should be attached to the ends of the box by means of cleats L and M or eyes and so fastened as to prevent slipping.

To operate this belt shifter, grasp the ropes anywhere between the box and the shifter bar, taking one rope in each hand, then pull down on one rope and lift up on the other in a direction to cause the box to assume a level position but continue until the weight box is tipped to the opposite 45-deg. position and the weight inside the box rolls to the downward end of the box, thus holding the shifter bar securely in its new position as indicated by the dotted lines L.

Should a more permanent and neater looking weight box be wanted, cut a piece of black pipe of proper length and diameter to contain the ball, screw a cap on each end of the pipe, attach a couple of screw eyes and you will have the neat looking box shown at O.

Indianapolis, Ind. JAMES E. HOBART.

Cleaning Steam

AS TO cleaning steam as discussed in recent issues, in 1925, the writer, as Supt. of Power for the Rochester Gas & Electric Corp., Rochester, N. Y., installed, for comparative tests, several types of internal steam purifiers. These were installed in the drums of 875-hp. Bigelow-Hornsby boilers and accurate and exhaustive tests were carried on over a period of six months. The performance of one of these purifiers was outstanding. It gave, at all times, steam of a quality equal or superior

to that of the other purifiers and throughout the entire range of boiler ratings, 50 to 300 per cent, had a much flatter efficiency curve. Scale was entirely eliminated from the super-heater tubes and cleaning of turbine blades became unnecessary. The device was found so efficient that all boilers were equipped. The period of blow down was not affected. The purifier requires absolutely no cleaning. Some 52 of them have been in service for several years and no cleaning has been found necessary.

In my opinion a purifier should be installed in any power boiler.

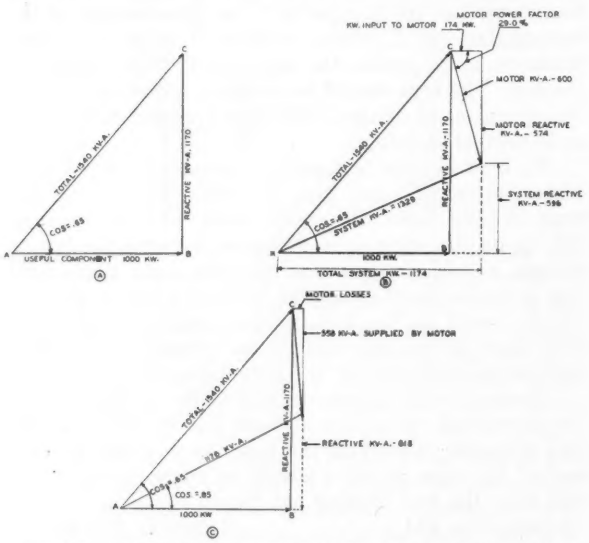
As a consulting engineer, I have had occasion to install a line purifier for exceptionally severe service, on the exhaust of a reciprocating pump. This pump takes steam at 400 lb. pressure and 540 deg. F. exhausting at 5 lb. The purifier has been in service on this line for several months. We have been unable to find a trace of oil in the exhaust and as the returns go to the feed water it is quite evident that no oil is going past the purifier.

The make of these purifiers can be had by writing to Power Plant Engineering.

Rochester, N. Y. C. A. WOODRUFF.

Determining Effects of Synchronous Motors on Power Factor

IN LOOKING OVER various engineering journals I notice that although the subject of power factor has been brought up a great many times and costs and descriptions of various installations given, no general method has been given for determining the resulting power factor in advance of the installation of a synchronous



VECTOR DIAGRAMS SHOWING POWER FACTOR RELATIONS UNDER VARIOUS CONDITIONS

motor. It would seem from this that the majority of plant engineers either are capable of figuring this out with no difficulty or that they must depend on outside engineering advice.

It would probably be of interest to give a method of computing power factor which is comparatively simple to follow through and is very accurate for this type of installation. This method will be the same for any case and values may be substituted for those assumed in the sample computation. For the sake of simplicity motor losses are neglected which will in most cases result in negligible error.

A. Assume a load on the system of 1000 kw.

Assume a power factor existing of 65 per cent.

$$\text{The total kv-a. will be } \frac{1000}{0.65} = 1540 \text{ kv-a.}$$

By the law of triangles the reactive kv-a. is $\sqrt{(1540^2 - 1000^2)} = 1170$ kv-a.

The useful component value may be taken from the wattmeter reading in most cases while the total kv-a. value will be the product of voltmeter and ammeter readings. The cosine of the angle, or power factor is the adjacent side AB (figure A) divided by the hypotenuse AC or

$$\frac{1000}{1540} = 0.65 \text{ or } 65 \text{ per cent.}$$

All readings as taken to make such computations should be taken at the same time and if on a varying load, they should be average values.

B. Suppose a load of 200 hp. may be driven by a synchronous motor rated at 600 kv-a. input, with an efficiency of 86 per cent. Computations for determining effect on power factor of the above system follow.

The kw. input to the motor will be

$$\frac{0.746 \times 200}{0.86} = 174 \text{ kw.}$$

The power factor of the motor will be

$$\frac{174}{600} = 0.29 \text{ or } 29.0 \text{ per cent.}$$

The reactive kv-a. of the motor will be

$$\sqrt{(600^2 - 174^2)} = 574 \text{ kv-a.}$$

The corrected reactive system kv-a. is the difference between 1170 and 574 or 596 kv-a.

The system kv-a. is now changed and is determined as follows:

New total kw. is 1000 plus 174 = 1174 kw.

Reactive system kv-a. as found above, 596 kv-a.

System kv-a. $\sqrt{(1174^2 + 596^2)} = 1329$ kv-a.

C. Suppose it is desired to correct a power factor with a synchronous motor running light. A power factor of 85 per cent is desired.

$$\text{The new kv-a. would be } \frac{1000}{0.85} = 1176 \text{ kv-a.}$$

The useful component remains the same, 1000 kw. and the new reactive kv-a. will be

$$\sqrt{(1176^2 - 1000^2)} = 618 \text{ kv-a.}$$

The synchronous motor running light supplies 1176 — 618 or 558 kv-a.

It may be seen from the above figures that in case B, the addition of a synchronous motor has reduced the total system kv-a. 211 and in the second case a reduction from 1540 to 1176 or 364 kv-a. has been made. This of course reduces the load on the generators (or purchased power), line losses and makes this power available for future additional load.

Boston, Mass. HARRY M. SPRING.

Is Paint an Insulating Material?

EVERY ONCE in a while I am told of someone who advocates the use of paint as an insulating material. For instance, just recently a man who was troubled with sweat on his cold piping wanted to know how to get rid of the sweat. A paint enthusiast told him to paint the pipe with a sticky paint and then sprinkle ground cork on the paint. He was told that the combination of sticky paint and cork would insulate the pipe sufficiently to eliminate future sweating.

There is no question but that paint, regardless of how thin the coat, and regardless of the kind of paint, does furnish a small amount of insulation. All materials are insulators. It would, however, take many thousands of coats of paint to be as effective as an inch of cork. Perhaps the total thickness of the coats of paint would have to be about 6 in. or even more to equal 1 in. of cork.

Sprinkling granulated cork onto sticky paint no doubt produces a better insulating material than the paint alone, but even that method would hardly produce sufficient thickness. My experience has been that there is nothing equal to or better than moulded cork pipe covering for eliminating pipe sweat. The correct thickness of the cork depends upon the degree of humidity in the air. The greater the humidity the greater the thickness of cork required. For average conditions a thickness of 1½ in. of cork will usually solve the problem. Where humidity is high, 2½ in. is frequently necessary to do away with the condensation.

Newark, N. J. W. F. SCHAPHORST.

Driving Conveyor Belt Idlers

IN AN ordinary conveyor belt drive where the power is supplied to the head pulley only, a severe strain is placed on the belt as it nears the head pulley, much greater than at other parts of the drive.

As the strength of the belt must be proportioned according to the maximum stress, the belt must be much thicker and stronger than is necessary to meet the average stress. The thicker the belt the larger must be the head and tail pulleys.

In order to overcome this difficulty due to the non-uniform stress in the belt, using a smaller motor on the head pulley and motor driving some of the idlers along the drive has been adopted in Germany. In some cases every other and sometimes every third idler is power driven. The motors are driven at such a speed that the surface of the idler equals the surface speed of the belt. The idlers are connected by a clutch so that they can be run free as plain idlers if so desired.

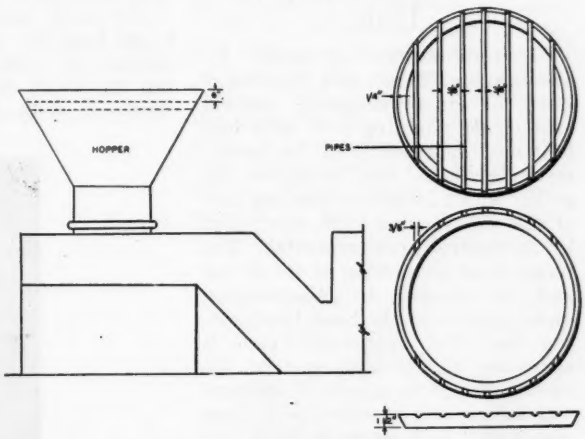
No more power is consumed by a drive of this sort for, while the idler motors take power, the power taken by the head pulley motor is proportionately reduced. The more uniform distribution of the stress enables a thinner belt to be used with correspondingly smaller pulleys. This solution has been found greatly to reduce belts cracking at the edges. In the case of existing troublesome belt drives, driving one or more idlers may give a solution.

Hertz, England. W. E. WARNER.

SWIMMING events at the 1932 Olympiad in Los Angeles will be illuminated by 40 special Westinghouse underwater lights, making every movement under water visible.

Pulverizer Protection

WE HAVE HAD DIFFICULTY with foreign substances, stones and wood, in our pulverizers. These materials pass the magnetic pulley and to prevent this we have made a screen to fit in the pulverizer hopper. This is round with the frame made of ¼ by 1½ in. flat iron with grooves cut in to hold a number of ⅜ in. pipes



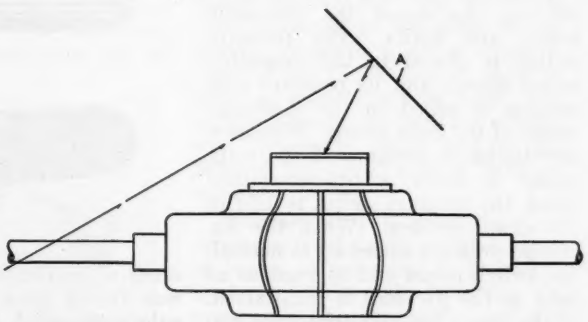
DETAILS OF GRATING FOR PULVERIZER HOPPER TO SCREEN OUT WOOD AND STONES

spaced to give a ⅝ in. opening. Pipe is better than solid iron bars because it turns and allows better passage of coal. This grating sets in the hopper about 6 in. from the top. We have been using this for some time with entire satisfaction and complete protection to the pulverizer. CHARLES MEHR, SR.

Seymour, Conn.

Improvised Light

SOMETIME AGO the writer had occasion to climb into an obscure corner to read a meter. Expecting that there would be enough light, he did not take a flashlight along and when he found that there was not, he was disappointed to find that he did not even have a match along.



There was no light from above but plenty below and to one side.

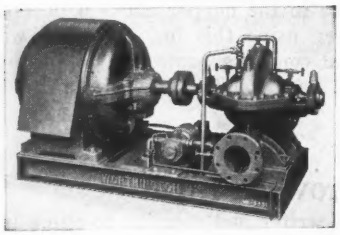
Finally he held the piece of white paper on which he expected to copy the meter reading as shown in the accompanying sketch and was able to reflect enough light on the dials to make the figures visible.

Coffeyville, Kansas. EARL PAGETT.

New Equipment

Centrifugal Pumping Unit

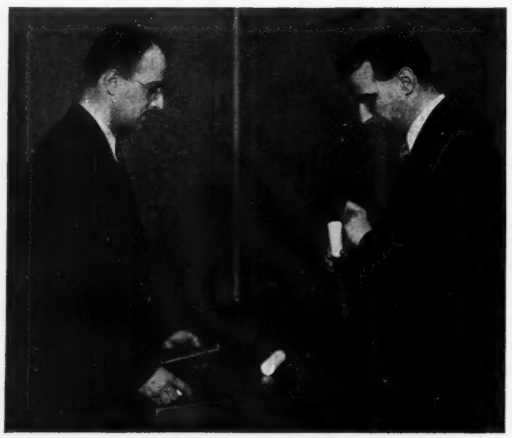
ANNOUNCEMENT is made by Worthington Pump and Machinery Corp. of an automatically primed centrifugal pumping unit, with ball bearings, mounted with its motor, on a fabricated steel bedplate, together with a Monobloc priming unit of the wet vacuum type, controlled by an electric pressure switch. The pump is an adaptation of the Hytor and is licensed to Worthington under patents of the Nash Engineering Co. The evacuator which is connected to the high spot of the suction volute by means of substantial tubing and is sealed with clear water held in a reservoir built into the bedplate of the complete unit, operates to remove air from the centrifugal pump, thereby causing it to be primed.



The evacuator motor is connected across the main pump motor line at a point between the starting switch and the motor, so that in starting the motor the evacuator motor also starts. The pressure switch is placed in the evacuator motor circuit and its pressure connection is piped to the discharge nozzle of the main pump. Whenever the discharge pressure of the main pump is below a pre-determined point, the pressure switch is held in the closed position. When the discharge pressure comes up to normal, the switch opens and so remains as long as the pressure is maintained. If the pump loses its prime, the discharge pressure naturally drops; the pressure switch is thereby closed causing the evacuator to operate until the pressure is again built up to normal. A check valve in the evacuator suction line prevents air leakage from the evacuator to the main pump when the evacuator is not in operation.

Boric-Acid De-ion Fuses

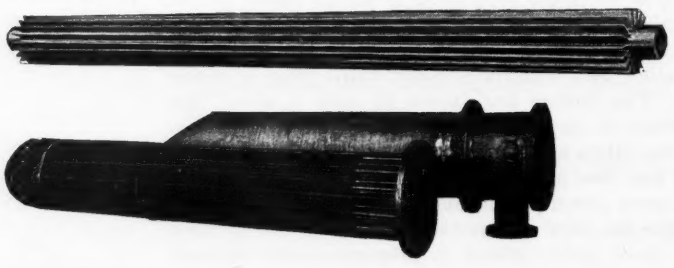
TO BREAK small currents at 110 v. the fuse is a simple and reliable device; but when it comes to breaking thousands of amperes at thousands of volts, fuses may become spectacular affairs, shooting or bursting. Hitherto this violence had been attributed to the formation of gas and engineers had sought materials which under the heat of the arc would evolve no vapor. Dr. Slepian of Westinghouse proved it was this very vapor evolution which extinguished the arc and said the cure for the trouble was some material which would yield maximum volumes of non-explosive vapor. This was found in a most unexpected substance, solid boric acid, which yields water vapor when heated.



From this starting point, Westinghouse engineers developed a fuse which breaks 20,000 amp. at 13,200 v. with no excitement. In the center of a thick-walled cylinder of solid boric acid is a plunger, which would be withdrawn deep into its hole by a spring, were it not held forward by the fuse-wire, which serves as one terminal. When the fuse melts, the arc is drawn down into the boric-acid hole, eliciting an outrush of water vapor which instantly extinguishes it. By special design, the fuse solves the difficult problem of interrupting very small currents as well as large ones.

Storage Oil Heater

RECENTLY placed on the market by The Griscom-Russell Co., New York City, this storage tank oil heater has a unique type of compact, effective heating element, consisting of U-shaped steel pipes with longitudinal fins along the exterior surface of the straight portions of each pipe. These fins are equally spaced about the circumference of the pipe and are securely fastened by a mechanical process.

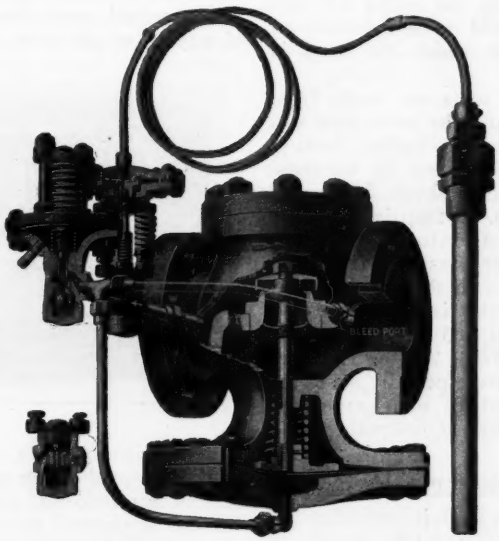


Total surface of the fins on each pipe is from 4 to 6½ times greater than that of a bare pipe of the same length and diameter. The heater is installed with the shell and heating

elements extending into the tank and the steam, drain and oil connections outside the tank, to heat oil locally at the point of withdrawal.

Combined Temperature-Pressure Regulator

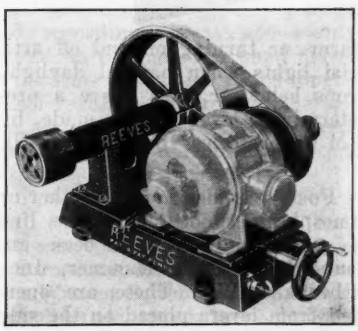
IN THIS self-contained regulator, to operate on any pressure above 1 lb., pilot valves may be operated by steam pressure. If steam pressure passed is below 1 lb., pilots can be operated by outside steam, compressed air or city water. Main valve sizes are ¼ in. to 12 in. Both pilot and main valves are single seated, closing tight if seats are free of dirt, the pressure control closing the main valve if pressure in the control pipe rises above a set value, so that separate reducing valve is unnecessary.



Seats and discs of both valves can be reground without taking the main valve out of the line. Steam comes in at the left. Main valve is held closed and pilot valves open by springs. Initial-pressure steam flows through the pilot valves faster than it can escape through the bleed port so that pressure on the main valve diaphram opens that valve. When temperature rise actuates the thermostat, it closes the temperature pilot, or if pressure in the delivery end gets too high, in either case shutting off steam flow to the main valve diaphram, so that the spring closes that valve. Strainers are built into the pilot valves and a strainer is recommended for the steam supply line to keep valve seats clear of dirt. The regulator is made by Spence Engineering Co., Inc., New York City.

Speed Control Unit

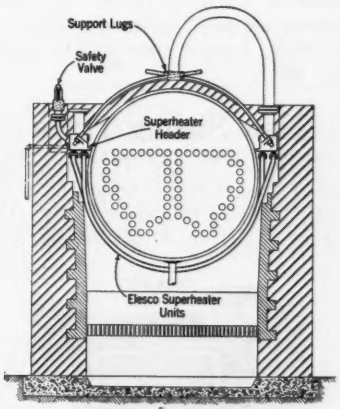
THIS NEW unit of the Reeves Pulley Co. embodies two opposing cone-faced discs, one stationary and one sliding, and an adjustable power compression spring, all mounted on the shaft of a standard electric motor. This assembly is mounted on a special sliding motor base, a V-belt forming the connection between the sliding discs and the driven pulley. A turn of the adjusting handwheel moves the motor and disc assembly toward or away from the driven pulley. As the motor pulley moves away from the driven pulley, the sliding disc moving out laterally, the V-belt travels over a smaller diameter between the discs and vice versa, thus effecting speed regulation. A ball bearing countershaft has on one end a flat-faced pulley to receive power from the Vari-Speed motor pulley. On the other end, any standard type of drive, such as pulley or sprocket can be



applied. The countershaft itself is adjustable on the base proper, which permits selection of pulley sizes to give speeds required.

Superheater for Return Tubular Boilers

THIS NEW superheater consists of two cast-steel headers, connected by detachable tubular elements which pass underneath the boiler. Steam goes from the boiler outlet to one header and passes from the other to the steam main. Headers are supported by adjustable clamp rods so that units may be raised or lowered to regulate the amount of superheating. This Elesco superheater, developed by The Superheater Co., gives to plants using horizontal return tubular boilers the advantages of superheated steam for process work or for generating power, without change of setting or arches.



Installation can be made by regular employes in the plant, operation is automatic and the greater efficiency of superheat operation is attained.

Glyptal Gaskets

IMPENETRABLE even by hot oil or gasoline is the statement made by General Electric Co. in regard to its gasket material No. 1281, which has been developed in the research laboratory. Tests on joints at temperatures of 210 to 230 deg. F. show no effect on gaskets and no leaks. The compound may be used in contact with cemented joints and is unaffected by dilute acid or alkaline solutions.

Number 1281 is a sulphur-free alkyd resin substance, odorless, gray or brown in color and is given the trade name Glyptal. It is flexible, practically incompressible and undergoes no noticeable hardening or stiffening on exposure to weather. Although at temperatures below 0 deg. F. it is somewhat brittle, this has no effect on its efficiency as gasket material in a joint. It has been tried out satisfactorily in bushing assemblies with porcelain, brass, cast iron and copper under widely

varying temperatures, pressure and contact with oil.

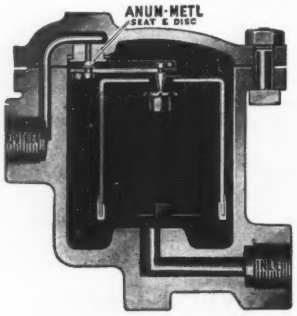
For bolted joints gaskets should be thin as possible with wide faces which are completely covered by the clamping surfaces, an enclosed gasket being preferable, though allowance should be made for transverse distortion during clamping. Except for severe exposure as to salt water no sticking substance is needed but, where needed a Glyptal varnish No. 1201 may be used as a cement.

Used as a sleeve for screwed joints, the surface should have a thin film of mineral oil when assembling to allow the parts to slide easily on the gasket.

At present it is available in sheets up to 13 by 36 in. and thicknesses of 1 mil. to ⅛ in.; in round gaskets up to 12½ in. diam. by ⅛ in. thick. Larger sizes will be available later.

New Strong Traps

NUMBER 70 and 71 Strong inverted bucket traps, which have recently been introduced by the Strong, Carlisle & Hammond Co.,



Cleveland, Ohio, embody new improvements in design and materials used. The anti-balancing principle vent hole in the bucket, so arranged that a very small vent is open while the trap is in the process of filling. As the bucket begins to lose weight (which is the point where the balancing usually occurs) the valve in the bucket is opened wide to permit a quantity of steam and air to escape suddenly, this being displaced with water which causes the bucket suddenly to lose its buoyancy, sinking and opening the trap discharge valve wide.

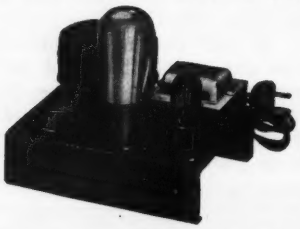
In the 70 Series traps, the bucket is suspended on a tapered spindle, the clearance between this spindle and the hole in the stainless plate consists of a valve arrangement which replaces the conventional air on the bucket serving as the air vent. While the bucket is floating or in a filling position, the clearance is small but, as the bucket starts to sink. this clearance increases rapidly and produces the effect described above. The manufacturers claim that the bucket moving up and down the tapered spindle prevents the air vent from becoming clogged with sediment or oil, hence these traps may be used satisfactorily on exhaust steam containing oil.

Tests conducted show that either the 70 or 20 Series traps fitted with the variable area air vent will handle considerably more air in a given time than the old type inverted trap with the plain air vent in the bucket, thus shortening the length of time required to build up temperature on the equipment which the trap is draining.

Discs and seats are made from Anum-Metal and the lever, pins and wear plate on the bucket from a steel which increases in hardness when subjected to shock, friction or wear. The No. 70 trap is made for pressures from 0 to 125 lb., the No. 71 trap for pressures from 0 to 200 lb., both with semi-steel bodies. The No. 71 trap is also furnished with cast steel body and cover for pressures from 0 to 200 lb. The steel bodied traps are especially made for installations where some superheat might be present at intervals.

Photoelectric Relay

FOTO-SWITCH unit embodies an electro-magnetic switch which is opened or closed by the interruption or variation in the illumination on the photoelectric cell, to control any sort of electrical device, such as motors, electric signs, signals, or



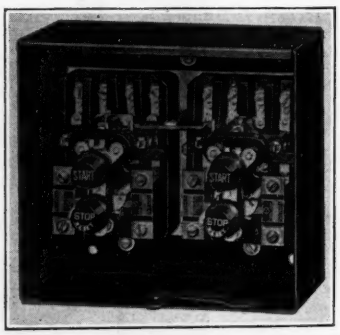
alarms or turning on and off artificial lights when natural daylight drops below or rises above a predetermined level. It is made by G-M Laboratories, Inc., Chicago, Ill.

FOR USE under severe weather or atmospheric conditions, a new line of master stations has been announced by Cutler-Hammer, Inc., Milwaukee, Wis. These are operated from levers placed on the side of the case, instead of from push buttons on the front, the shafts of the levers operating through stuffing boxes, and the cover joint being sealed by a rubber gasket.

Manual Starters

TWO SPEED separate winding type and single speed reversing type starters for controlling across-the-line motors are recent additions to the line of a. c. manual starters manufactured by Industrial Controller Division, Square D Co., Milwaukee, Wis. Both types have general application, but the two speed type is especially suitable for heating and ventilating purposes and similar installations where remote control is not essential.

Outstanding features of these starters are: front operation, thermal overload protection, operation of any relay opens main line com-



pletely disconnecting motor from line, two quick-break switch mechanisms interlocked to prevent simultaneous operation, and push button reset without replacement of any parts after an overload.

Maximum dimensions are: 13⅜ in. wide, 10⅞ in. high and 5½ in. deep. The maximum horsepower ratings of the three pole starters are 5 hp. at 220 v. and 7½ hp. at 440-550 v.

Westinghouse Fractional Horsepower Motors

ANNOUNCEMENT by O. F. Stroman, manager of the industrial department of Westinghouse Elec. & Mfg. Co. of the development of a new line of capacitor motors and redesign of other small motors is evidence of anticipation of an early return of industrial activity. Frames, shafts, bearings and mountings are interchangeable for various types, five frame sizes serving the entire line from 1/30 to ¾ hp. The capacitor type is the first to be put into production, others to follow as necessary changes in shop equipment are completed. Resilient spring mounting is provided to nullify the inherent vibration of the 60-cycle, a.c. motors, which is due to the change of current direction 120 times a second.

Isometer Flow Meter

THIS CONSISTS of the actuator, (1) which is located in the pipe line and whose movements are transmitted to and measured by the meter. The actuator is a horizontal flanged section in the center of which is securely fastened a set of nitralloy, or stainless steel plates forming a variable rectangular orifice. Built into the horizontal section and directly above the orifice is a perpendicular cylinder with a floating piston (18) through which extends a stem (8) guided at top and bottom. The lower end of this stem is fastened to an accurately fitted tongue (13) which, at zero flow, completely closes the orifice and is equipped with two shearing points that effectively remove any foreign matter from the guiding grooves.

Restriction caused by any orifice results in pressure drop which depends upon the relation between the size of the orifice and the quantity being passed through it, large flow through a small orifice giving extreme pressure drop, while small flow through a large orifice would have no measureable drop. In the

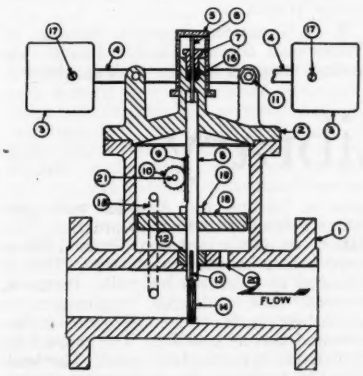


FIG. 1. SECTION OF ACTUATOR

Isometer the orifice area is variable, following exactly every change in the flow, the differential pressure being set for a definite constant value. Measurement is taken of the size of the orifice which varies exactly as the flow.

Initial fluid pressure is applied to the lower side of the floating piston (18) through a port (20) in the base of the cylinder, causing the piston and stem to rise and opening the orifice. The downstream pressure is applied through tube (15) to the upper side of the floating piston. Downward mechanical load on the piston, from the two levers (4) of weights (17) bearing on cap (5), equals the desired differential pressure exerted over the area of the piston. The orifice will open until

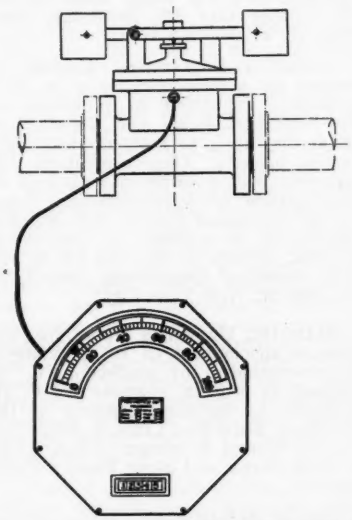


FIG. 2. ARRANGEMENT OF ACTUATOR AND METER

the downstream pressure, above the piston, combined with the mechanical load, equals the upthrust resulting from initial pressure below the piston.

Rack (9), mounted above the piston on the stem, turns a gear and shaft (21) through 140 deg., the shaft being brought out either directly into the meter body or, in the remote type meter, coupled to a flexible shaft which is led to the meter body through a brass tube.

For pulsating flow where the flow surges are great, small pressure ports are used to dampen the response without affecting accuracy.

Divisions on the indicating scales and recording charts are evenly spaced, as the indicator hand moves in the same proportion as the tongue which regulates the area of the orifice, scales and counters being direct reading in the unit of calibration desired.

Integration of readings is by a small compound wheel held in contact with the face of a rubber-covered rotating disc which is driven by a Warren Telechron clock motor. Proportionate speeds are obtained by rotating the axis of the compound wheel in relation to the tangent of the disc. This action may be likened to a variable pitch screw, the rotation of the screw being constant but the travel changing as the pitch changes. The counter operates continuously when the meter is in operation, every movement of the indicator hand changing the rate of integration, so that varying and pulsating flows are accurately totalized.

Meter body is dust proof, finished in flat black, with cadmium plated rim. For pressures over 250 lb. actuator bodies are of bronze, others are regularly made of nickel cast iron, but can be furnished in bronze, cast monel metal, or cast steel if desired. Scales have black numerals on white background, the pointer being bright red.

This equipment is made by Isometer Co., Milwaukee, Wisc.

Henry H. Kerr

MR. KERR, vice-president of United Engineers & Constructors, Inc., died in Chicago July 20 of a heart atack at the age of 68. His business career was closely associated with Westinghouse - Church - Kerr & Co., a corporation formed to sell products of Westinghouse Machine Co. in the '80's and, later, products of Westinghouse Electric Co. and Union Switch and Signal Co. Henry Kerr joined the sales company in 1885 as bookkeeper and cashier in the New York office, going 2 yr. later to the Chicago office as assistant manager and eventually taking charge of the office. In 1918 he became vice-president of Westinghouse-Church-Kerr & Co., held the same position with Dwight P. Robinson & Co., Inc., when the former company was merged with the latter and in 1920, when the Robinson Co. became part of United Engineers and Constructors, Mr. Kerr became vice-president of that organization.

He believed in cultivating business associations over long periods, closing some contracts after 10 yr. of effort. Railroad business was his specialty, travel of 50,000 miles being to his credit in following up new shop and terminal projects.

TO COLLECT sanitary sewage from all structures in the Century of Progress grounds for the 1933 Chicago World Fair and deliver it to the city sewers at a slightly higher elevation, four underground automatic pumping stations will be used, each having three direct-driven, vertical-shaft units of 1300 to 5700 g.p.m. capacity. Contract for building equipping and operation during the period of the Fair has been awarded to Yeomans Brothers Co.

News From the Field

FOOTE BROTHERS Gear & Machine Co. announces the appointment of Urquhart Service, 2133 Blake Street, Denver, Colo., as its representative in Colorado and Wyoming. Also, Briggs-Schaffner, Winston-Salem, North Carolina, was recently appointed district representative for the states of North and South Carolina.

FALK CORP., Milwaukee, announces the appointment of L. A. Graham and M. A. Carpenter as sales manager and sales promotion manager respectively for all commercial products. Foundry sales remain under the direction of A. Simonson, vice-president.

BABCOCK & WILCOX Co. announces that all purchasing will be concentrated at its Barberton, Ohio, Works after September 1, 1932.

A. M. CASTLE & Co. has been appointed sales distributor and sales agent for the Babcock & Wilcox Tube Co. in the Chicago district and Pacific coast territories. Warehouses are maintained in Chicago, Seattle, San Francisco and Los Angeles for stocks of boiler tubes and the Castle company will sell for mill shipment all B. & W. Tube Co. products, cold drawn or hot finished, ½ in. to 8⅝ in. made to any commercial analysis. C. C. Moore & Co., agents for B. & W. Co., will continue to sell and service retubing jobs for B. & W. and Stirling boilers on the Pacific coast.

EXHIBITORS COMMITTEE Industrial and Power Shows, Inc., has removed its office to 23rd floor, 330 W. 42nd St., New York, N. Y.

KELL-RAPH copper plated gaskets are described in a 4-p. folder issued by M. W. Kellogg Co., 225 Broadway, New York, N. Y.

AMERICAN ENGINEERING COUNCIL is sending out a communication to its state committees explaining the provisions of the Emergency Relief and Construction act as they apply to engineers and engineering projects. These committees will cooperate with governmental agencies in relieving destitution, recommending loans for self-liquidating projects and obtaining employment for engineers on construction projects. Details of the plans can be had from American Engineering Council, 29 W. 39th St., New York City.

MANNING, Maxwell & Moore, Inc., announces appointment of F. J. Winterer as superintendent of production, G. A. Mitchell as proposal engineer and C. H. Schramm as designing engineer of the subsidiary Shaw-Box Crane & Hoist Co., recently formed by merger of Box Crane & Hoist Corpn. and Shaw Electric Crane Co.

MERCON Regulator Co. announces appointment of the following district representatives: The Laney Co., Kennedy Bldg., Tulsa, Okla.; Ambler & Riter, Inc., 810 14th St., Denver, Colo.; L. J. Riter, Kearns Bldg., Salt Lake City, Utah; Hughes Machinery Co., Mfrs. Exchange Bldg., Kansas City, Mo.

PHILADELPHIA Technical Service Committee, 1317 Spruce St., Philadelphia, Pa., is conducting a campaign to bring engineers and employers in touch with each other without charge to either. Some 900 technically trained men, fitted for key positions are available.

DIESEL Engine Manufacturers' Assn. at a recent meeting, elected H. Birchard Taylor of Philadelphia president, succeeding George W. Codrington of Cleveland, who was elected chairman of the board. E. T. Fishwick continues as chairman of the executive committee. Mr. Taylor graduated from the University of Pennsylvania in 1905, entered the drafting room of the hydraulic department of the I. P. Morris Co. and in 1911 was made hydraulic engineer. In 1915 he was appointed assistant to the president of the William Cramp & Sons Ship and Engine Building Co. and was elected vice-president in 1917. During his career Mr. Taylor has been president of the De La Vergne Machine Co., the Federal Steel Foundry Co., the Atlantic Coast Shipbuilders' Association, vice-president and member of council of the American Society of Mechanical Engineers and is now consulting engineer to the Baldwin Locomotive Works.

J. B. TROTMAN, formerly manager of Philadelphia Branch, Goulds Pumps, has become manager of the Chicago branch.

For the Engineer's Library

THE QUEST FOR POWER. By Hugh P. and Margaret W. Vowles. Published by Chapman & Hall, Ltd., 11 Henrietta St., Covent Garden, London, W. C. 2 England. Cloth, 6 by 9 in. 341 pages.

Man's endeavor to augment his own bodily power is perhaps his greatest adventure. Fragmentary portions of this adventure have been dealt with in detail before but this book records the story not in statistics of pressures and temperatures, 100,000 and 200,000 kw. turbines but by the effect this quest had on the development of our civilization.

Specialization is ordinarily considered a result of the Machine age yet man began to specialize in the Neolithic age and the story of his struggle to perfect tools, control water, measure time, work iron and develop transportation make fascinating reading.

This apprenticeship of toil as it is named, was preliminary to the age of power which began in earnest in the seventeenth century It is surprising to find how close the ancients came to the useful development of water, wind, coal, oil and metals in the centuries before the Christian era. The extensive sewage and water supply system of Babylonia, the irrigation systems of the Nile and Euphrates, the Royal Road of the sixth century B.C., the aqueducts of the Romans, water clocks, fire engines with pistons and cylinders machined in a lathe, slot machines, a machine gun and even a taximeter for chariots record the struggle of man to master materials.

The second part of the book, the age of power covers the period from about 1100 A.D. to the present day while in the third book is covered the past and present methods of mining and treating fuels and metals which made the modern power plant possible. The book concludes with a chapter on the significance and possibilities of the World Power Conferences and a glance at some of the possibilities of future developments in power engineering.

DIESEL REFERENCE GUIDE. By Julius Rosbloom. Published by the Industrial Institute, Inc., 897 Bergen Ave., Jersey City, N. J. Cloth 8½ by 10 in. 292 pages. Price $4.00

Data and text prepared as a guide and instruction book for engineers and those interested in Diesel engines. Principles and theories covered in the first part are followed by chapters on various parts of the engine, water problems, supercharging, oil, electric locomotives, aircraft and automotive engines. Section II of the book lists manufacturing establishments, engineering firms and commercial houses in the field of Diesel engineering and allied industries.

PULVERIZED FUEL FIRING. By Sidney H. North. Published by Isaac Pitman & Sons, 2 West 45th St., New York, N. Y. 5x7½ in. Cloth. 187 p. Price $2.25.

Concise and up-to-date work on the use of pulverized fuel for power generation, industrial furnaces and marine installations in Europe and America with particular reference to English practice. The history of pulverized coal from 1818 is given briefly in the introduction. This is followed by chapters on mills, furnaces, burners, dust collection, application to Lancashire boilers, metallurgical industries and marine practice. The chapter on combustion is particularly good. The book is not a textbook but a short, well prepared and interesting general treatise on the present practice in pulverized coal firing. It should be of particular interest to those interested in but not actively engaged in the use of pulverized fuel.

FUNDAMENTALS OF ELECTRICITY (Allegemeine Grundlagen der Electrotechnic). By C. Michalke, 6 by 8 in., cloth, 167 pages. Price 5 reichmarks.

Electric Railways (Elektrische Bahnen). By A. Horing, 6 by 8 in., cloth, 515 pa. Price 15 reichmarks.

Both published by Walter de Gruyter & Co., Berlin, W.10, Germany.

Two volumes in German from the Siemens Handbook series well prepared and illustrated with halftones, line cuts and plate inserts. The treatment is simple and intended to inform the younger electrical worker and general reader as well as the expert. Modern usage is featured, the illustrations in general being drawn from the practice of Siemens-Schuckertwerke.

COMFORT. COOLING WITH ICE, by Emerson Brandt and Lee Currey, published by the National Association of Ice Industries, 163 W. Washington St., Chicago.

Size 8½ by 11, 7 sections, with fabricoid cover. Price, first copy, $5.00; additional copies, $3.00.

Published as a manual on comfort cooling with ice by the Technical Division of the Association. This manual fills the long-felt need of the ice industry and those interested in air conditioning by compiling the available information in usable form. Section 1 is a brief explanation of air conditioning and comfort cooling with an explanation on how the cooling is accomplished. Section 2 is the basic organization of a selling plan, giving information on such subjects as sales policy, sales programs, organization and equipment. Section 3 is a sales manual designed for the salesman with such information and data as he will need. Section 4 is photographs of installations now in service with appropriate advertising material to form a basis for an advertising campaign. Section 5 is a model proposal. Section 6 is intended to serve as a basis of a complete file of data from equipment manufacturers. Section 7 is a technical manual prepared to serve as a guide for the supervising engineer in his study of the fundamentals of comfort cooling and to bring about an understanding of the part ice plays in the development. The manual is not intended as a complete answer to any particular problem but rather as a help to a more complete understanding of all the problems involved.

Owners of the complete manual may buy additional individual paper bound sections as desired, the price ranging from $0.10 to $0.65 per section.

PRINCIPLES OF REFRIGERATION, by W. H. Motz. Published by Nickerson & Collins, 433 N. Waller Ave., Chicago, Ill. 6 by 9 in, 992 pages Price, cloth $7.50, full Morocco $8.50.

In this, the third edition of a book too well known to need detailed description, much of the original material has been rewritten and rearranged with over 300 pages added to bring the work up-to-date. Higher mathematics have been avoided and the text is in everyday language easily understood.

In addition to the fundamental principles of refrigeration chapters on various systems and refrigerants, chapters on practical air conditioning, erection, care and testing of apparatus and economies of refrigeration make the book of special interest to operating refrigeration engineers. The book is intended to give the refrigeration engineer complete and modern knowledge of the theory and practice in this field. The book is used by the N.A.P.R.E. in their national lecture course and E. S. Libby, professor of refrigeration, Armour Institute of Technology and H. G. Venemann, professor of refrigeration, Purdue University, chairman and member respectively of the Educational and Examining Board of the Association collaborated with the author in the preparation of the book.

BIBLIOGRAPHIES of vibrations in shafts, vibration measurements and design of crankshafts are given in a bulletin, Research Series No. 39, published by the Engineering Experiment Station, Purdue University, Lafayette, Ind. The booklet is 6 by 9 in., has 107 pages and sells for $1.00.

HOW TO AVOID faulty concrete in small structures is told in detail in Extension Series No. 27 bulletin published by Purdue University, Lafayette, Ind. The booklet is paper bound, 6 by 9 in., has 152 pages and tells how to proceed from the first mix to the finish in order to get concrete comparable with that in large structures poured under close control.

YOUR HEALTH AND YOUR EARNING POWER. Published by the National Electric Light Association, 420 Lexington Ave., New York City. 5½ x 8½ in., 181 pages. Price, paper $0.50; cloth $0.60.

Intended for distribution to employes of member companies, this book is instructive and non-technical, setting forth the mechanism and structure of the body, foods, correct living habits, personal hygiene, disease prevention, first aid, care of patients and first aid to the injured including the prone pressure method of resuscitation. Two qualified physicians and surgeons and an experienced industrial nurse worked together with the committee for two years in the preparation of the book.

ECONOMICS FOR ENGINEERS. By Edison L. Bowers and R. Henry Rowntree. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y. 6 by 9 in. Cloth, 478 pages.

Modern business life demands of the engineer a knowledge of the fundamentals of economic principles. The book is prepared as a textbook for engineering students and as such its arrangement departs somewhat from the usual economics text in that it is as concise as possible; marketing, investment and insurance have been included for completeness and value has been subjugated to cost with pricing much more practical than is usual. Chapters on financial structures, investments, insurance, socialism, government finance and the public control of business are particularly good.

INSERT A on steel sheet piling, illustrating its use for piers, locks, sea-walls, bulkheads, foundations, cofferdams and trench walls is issued by Carnegie Steel Co., Pittsburgh, Pa.

RESEARCH DEPARTMENT of the National Radiator Corp., Johnstown, Pa., has issued bulletin Report CP-6, describing the features of design and construction of the new National condensing and cooling sections and giving the results of tests made on these sections.

WELDING Ferrous Metals is treated in a series of bulletins by A. J. Moses, issued by Hedges-Walsh-Weidner Co., Chattanooga, Tenn.

NEW PORTABLE foot-candle meter for measuring illumination at any location is described in a folder sent out by Weston Electrical Instrument Co., Newark, N. J.

GAS ELECTRIC SETS for Every Application is the title of an illustrated eight page publication, C. 1959, recently issued by the Westinghouse Electric and Manufacturing Company. The sets are designed for furnishing continuous or auxiliary power supply for construction camps, barges, dredges, oil and gas wells, excavating operations, wharves, docks, loading platforms, ships, lumber camps, mines, quarries, radio stations, sign boards, traveling shows, theatres, schools, hotels, airports, airways and steam railroads. They are also suitable for all kinds of emergency service.

PUBLICATION GEA-897B recently issued by General Electric Company describes Air Cooled Transformers, for reducing voltage, balancing voltage, boosting voltage, insulating circuits and phase changing.

Bulletin GEA-1586 on Electric Equipment for woodworking supersedes publication 41521B on the same subject.

CENTRIFUGAL pumps for large outputs, as in waterworks pumping stations, are described in Catalog B-4, issued by the De Laval Steam Turbine Co., Trenton, N. J. Casing is split horizontally along the axis of the shaft, with piping connections in the lower part of the casing. Wearing rings of the labyrinth type protect the casing and impeller at the joints where the suction chamber is separated from the discharge chamber.

SUPERHEATERS for h.r.t. boilers as made by The Superheater Co., 60 E. 42nd St., New York, N. Y., are described in its bulletin T-22.

ENGINEERING Data, Industrial Rubber Goods is the title of a condensed catalog of the B. F. Goodrich Rubber Co., Akron, Ohio. Rubber belting, conveyor belt, hose capacity, packings, are some of the subjects treated.

COCHRANE CORP., 17th St. and Allegheny Av, Pittsburgh, Pa., is sending out Bulletin 692, discussing the advantages of continuous blow-down with heat recovery and describing its system and equipment for that purpose.

FOUR TO SIX Per Cent Chromium Steel Tubes and Pipe is the title of a new 16-p. bulletin issued by The Babcock & Wilcox Tube Co., Beaver Falls, Pa. It gives their advantages for refinery and other services, also data on four to six per cent chromium steel with tungsten and molybdenum.

ILLUSTRATED descriptions of every principal product manufactured by The Babcock & Wilcox Company, 85 Liberty Street, New York, are contained in the latest publication issued by that organization, also the operating characteristics of modern equipment for power, industrial, and process plants, as a guide to lower operating costs.

BULLETIN No. 28 of National Aluminate Corpn., 6216 W. 66th Place, Chicago, Ill., treats of the use of Nalco No. 8 as an anti-incrustant or scale retarder in feed lines, heaters, pumps, condensers, cylinder jackets, heat exchangers and the like. Bulletin No. 29 is on Nalco No. 41 for use in clarification of water through pressure filters for beverages, cooking, process work, swimming pools, ice plants and other like purposes.

K-MASTER Midget inverted bucket steam trap is announced in a leaflet issued by Kaye & MacDonald, Inc., West Orange, N. J.

IN A 4-p bulletin, T-112, Murray Iron Works Co., Burlington, Ia., illustrates and describes its newly developed unit heaters for motor or steam-turbine drive.

THERMODYNAMICS. By J. E. Emswiler. Published by McGraw-Hill Book Co., 330 West 42d St., New York, N. Y. Third Edition, size 6 by 9 in., cloth, 337 p. Price $3.00.

Probably no book on this basic subject has received better or more logical presentation both for the beginner or for review purposes. The presentation follows a logical course from simple, familiar steam cycles up through refrigeration and gas cycles to the theoretical and somewhat abstract theory, which is left until the last. Illustrations are simple and to the point. The book is too well known to need a detailed review. In this third edition a considerable portion of the text has been rewritten and new material added. Among the new material are two ammonia tables; an extensive treatment of the absorption system and use of solutions in power cycles; the theory of the wet bulb thermometer; gas turbines; supercharging and supersaturated steam.

Power Plant Construction News

Ala., Bessemer—Jefferson County Board of Commissioners, Birmingham, Ala., plans installation of pumping machinery and other power equipment, tanks, etc., in connection with new sewage disposal plants at Bessemer and Ensley, Ala. Each unit will cost about $225,000. Fuller & McClintock, 170 Broadway, New York, are consulting engineers.

Ark., Clarksville—Clarksville Ice Co., plans one-story ice-manufacturing plant on East Main Street, estimated to cost about $40,000, with equipment.

Calif., Arcadia—Imperial Products Co., care of Carl M. Einhart, 279 East Foothill Boulevard, Arcadia, president, plans installation of electric power equipment in proposed new dry ice-manufacturing plant near Salton Sea, Imperial Valley District, where property has been acquired, estimated to cost about $100,000.

Calif., Los Angeles—Board of Power and Light Commissioners, 207 South Broadway, is arranging to make application to Reconstruction Finance Corporation, Washington, D. C., for loan of $32,000,000, proceeds to be used for construction of steel tower transmission line from Hoover Dam, Boulder, Nev., to city limits, and for municipal electric light and power plant in harbor district at Wilmington.

Calif., Paso Robles—Board of City Trustees is considering installation of equipment for a municipal electric light and power plant, using Diesel engine units, and will secure estimates of cost at early date. Lillian Henry, city clerk, is in charge of preliminary work.

Calif., San Francisco—Best Foods, Inc., 88 Lexington Avenue, New York, plans installation of motors and other power equipment in proposed multi-story plant addition at 1900 Bryant Street, San Francisco, entire project estimated to cost about $100,000.

Calif., Torrance—Columbia Steel Corporation, Torrance, a subsidiary of the United States Steel Corporation, 71 Broadway, New York, plans installation of electric motors and other power equipment in connection with an expansion and improvement program, including new one-story addition, estimated to cost close to $400,000.

Colo., Englewood—Municipal Power Development Co., Pence Building, Minneapolis, Minn., has contracted with City Council, Englewood, for construction of a municipal electric light and power plant, to be one-story, 80 x 100 ft. Installation will include oil engine-generating units and auxiliary equipment, as well as pumping station, elevated steel tank and tower and equipment for municipal waterworks. Project is estimated to cost about $600,000.

Conn., Thomaston—Seth Thomas Clock Co., South Main Street, plans installation of motors and other power equipment in proposed new plant addition, entire project reported to cost about $40,000.

Ind., Butlerville—Board of Directors, Indiana School for Feeble Minded, Butlerville, has plans under way for modernization and improvements in power house, including installation of boiler and auxiliary equipment. Charles A. McGonagle, Fort Wayne, Ind., is superintendent. Charles Brossman, Chamber of Commerce Building, Indianapolis, Ind., is consulting engineer.

Iowa, Centerville—Iowa Southern Utilities Co., Centerville, is planning construction of a transmission line in Union and Adair Counties, with power substation facilities. Application for permission has been made.

Kan., Woodston—Common Council is said to be planning installation of pumping machinery and auxiliary equipment in connection with extensions and betterments in municipal waterworks. E. T. Archer & Co., New England Building, Kansas City, Mo., are consulting engineers.

Md., Ellicott City—Potomac Electric Power Co., Washington, D. C., is planning construction of a new steel tower transmission line from point near Ellicott City to connection with system in vicinity of Washington, including construction of a 100,000-hp. capacity power substation and switching station. Company has contracted to use power from new hydroelectric generating plant of Safe Harbor Water Power Corporation, Baltimore, Md., at Safe Harbor, Pa., and will make connection near Ellicott City. Entire project will cost close to $300,000.

Minn., Morris—At a special election, a bond issue of $150,000 has been authorized, fund to be used for construction of a municipal electric light and power plant. It is expected to place work under way at an early date. Robert J. Torrens, Shubert Building, St. Paul, Minn., is consulting engineer.

Miss., Poplarville—City Council has plans for a municipal electric light and power plant, and electric-operated pumping plant for water system, and plans early installation. Cost about $100,000, with equipment. Vinson B. Smith, Jr., Gulfport, Miss., is architect and engineer.

Mo., Doniphan—Current River Power Co., 605 R. A. Long Building, Kansas City, Mo., and its affiliated interest, Doniphan Hydro-Electric Co., have preliminary surveys under way for a proposed hydroelectric generating plant at Gartman Rock on Current River, vicinity of Doniphan. Work will include a power dam 3000 ft. long and 100 ft. high, with hydroelectric generating station of 26,000-hp. capacity, and is estimated to cost over $1,500,000. Holland, Ackerman & Holland, Inc., 20 North Wacker Drive, Chicago, Ill., is consulting engineer. E. B. Johnston is president.

Mont., Havre—Great Northern Railway Co., Railroad Building, St. Paul, Minn., has preliminary plans under consideration for a new power plant at Havre. Boilers will be equipped to use pulverized coal, with installation of pulverizing and coal-handling equipment. Estimated cost close to $100,000. T. D. McMahon, address noted, is company architect, in charge.

Neb., South Sioux City—City Council is considering construction of a municipal electric light and power plant, estimated to cost about $100,000, with equipment. It is proposed to arrange a bond issue at an early date. W. E. Buell & Co., Insurance Exchange Building, Sioux City, Iowa, are consulting engineers.

N. J., Kenvil—Hercules Powder Co., Delaware Trust Building, Wilmington, Del., has authorized an expansion and improvement program at power plant at powder works, Kenvil, including installation of two 500 hp. boiler units, new high pressure steam turbine and auxiliary equipment. Work is estimated to cost about $125,000. Company engineering department is in charge.

N. C., Lincolnton—Southern Public Utilities Co., Charlotte, N. C., is said to be planning construction of new transmission line in vicinity of Lincolnton, totaling about 24 miles. Cost close to $32,000. Company engineering department in charge.

N. D., Fargo—Board of Public Works plans extensions and improvements in municipal waterworks, with installation of pumping machinery, storage tank, filtration equipment, water softening apparatus, etc. Entire program will cost close to $100,000, and fund has been authorized in budget for fiscal year.

Ohio, Columbus—Department of Public Service, William P. Halenkamp, director, plans installation of power equipment, pumping machinery, tanks, conveying equipment and other mechanical apparatus in connection with proposed sewage disposal plant on Frank Road. Entire project reported to cost about $3,500,000. Robert H. Simpson is city engineer; John H. Gregory, John Hopkins University, Baltimore, Md., is consulting engineer.

Ore., St. Helens—City Council has appointed a committee to determine details regarding proposed municipal electric light and power plant, using Diesel engine-generating units. Cost is estimated at close to $200,000.

Pa., Altoona—The Penn Central Light & Power Co., Altoona, plans extensions in power substation in Pleasant Valley district, with installation of additional equipment, and extensions in transmission and distributing lines in that section. Program is estimated to cost about $175,000. Company engineering department is in charge.

Texas, Goose Creek—Municipal Telephone & Utilities Co., Pioneer Trust Building, Kansas City, Mo., has closed negotiations with City Council, Goose Creek, for construction of a municipal electric light and power plant, with installation to include two electric generating sets of 750 hp. capacity, each. Transmission line will be built to serve several neighboring communities. Project is estimated to cost about $300,000, with equipment. Work will soon be placed under way.

Texas, Sulphur Springs—City Council has preliminary plans under way for a municipal electric light and power plant, estimated to cost close to $80,000. Burns & McDonnel Engineering Co., Interstate Building, Kansas City, Mo., is consulting engineer.

Va., Norfolk—Board of Trustees, Robinson Industrial Home for Boys, O. J. Egerton, Law Building, Norfolk, treasurer, plans steam power house for central heating service at new school group on Kempsville Road, Princess Anne County, Va. Entire project estimated to cost over $1,200,000. Calrow, Browne & Fitzgibbon, Royster Building, Norfolk, are architects.